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(54) **SINGLE ACTION TISSUE SEALER**

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See application file for complete search history.

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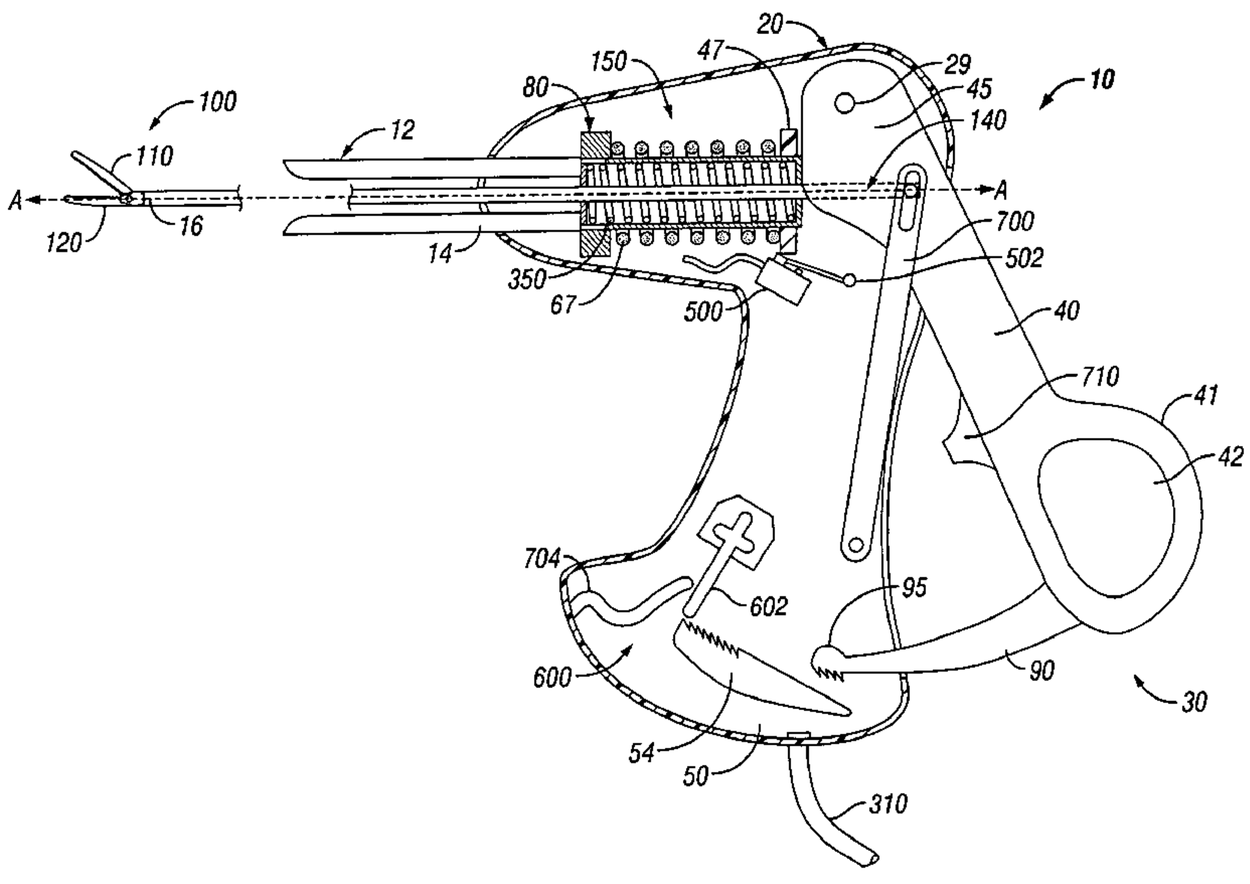
(57) **ABSTRACT**

An endoscopic bipolar forceps includes a housing and a shaft, the shaft having an end effector assembly at its distal end. The end effector assembly includes two jaw members for grasping tissue therebetween. The jaw members are adapted to connect to an electrosurgical energy source which enable them to conduct energy through the tissue to create a tissue seal. A drive assembly is disposed within the housing which moves the jaw members. A switch is disposed within the housing which activates the electrosurgical energy. A knife assembly is included which is advanceable to cut tissue held between the jaw members. A movable handle is connected to the housing. Continual actuation of the movable handle engages the drive assembly to move the jaw members, engages the switch to activate the electrosurgical energy source to seal the tissue, and advances the knife assembly the cut the tissue disposed between the jaw members.

14 Claims, 16 Drawing Sheets



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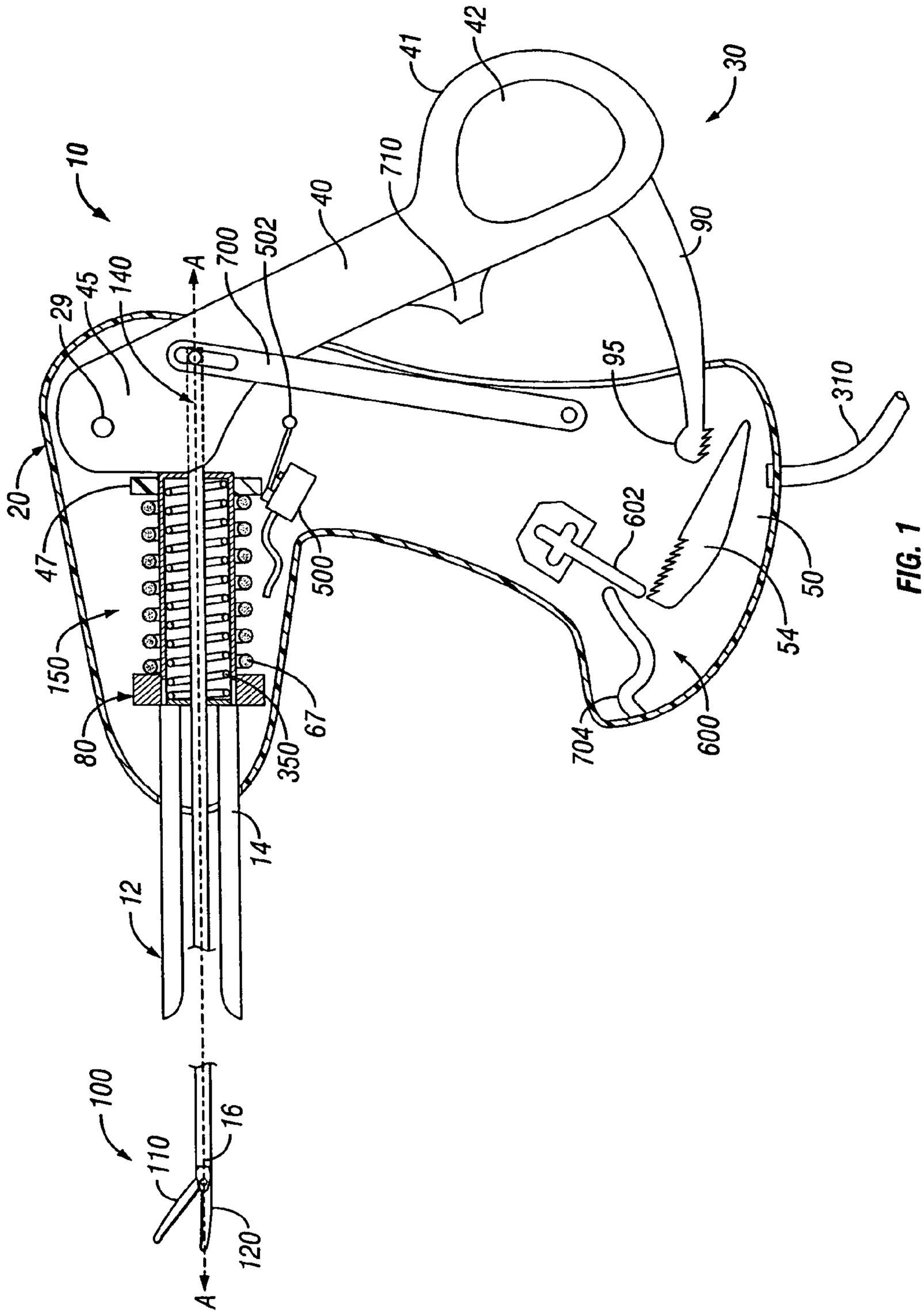
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FIG. 1

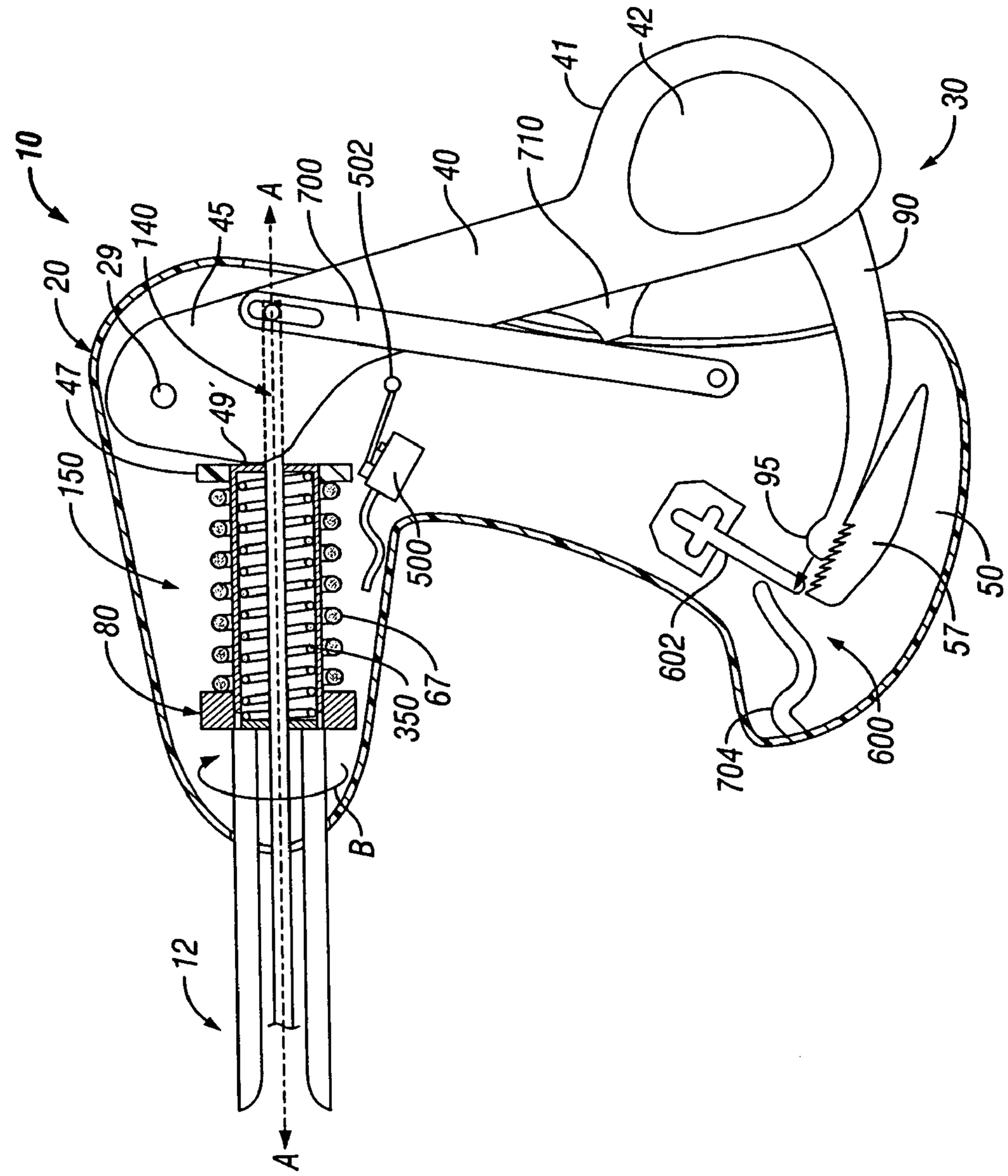
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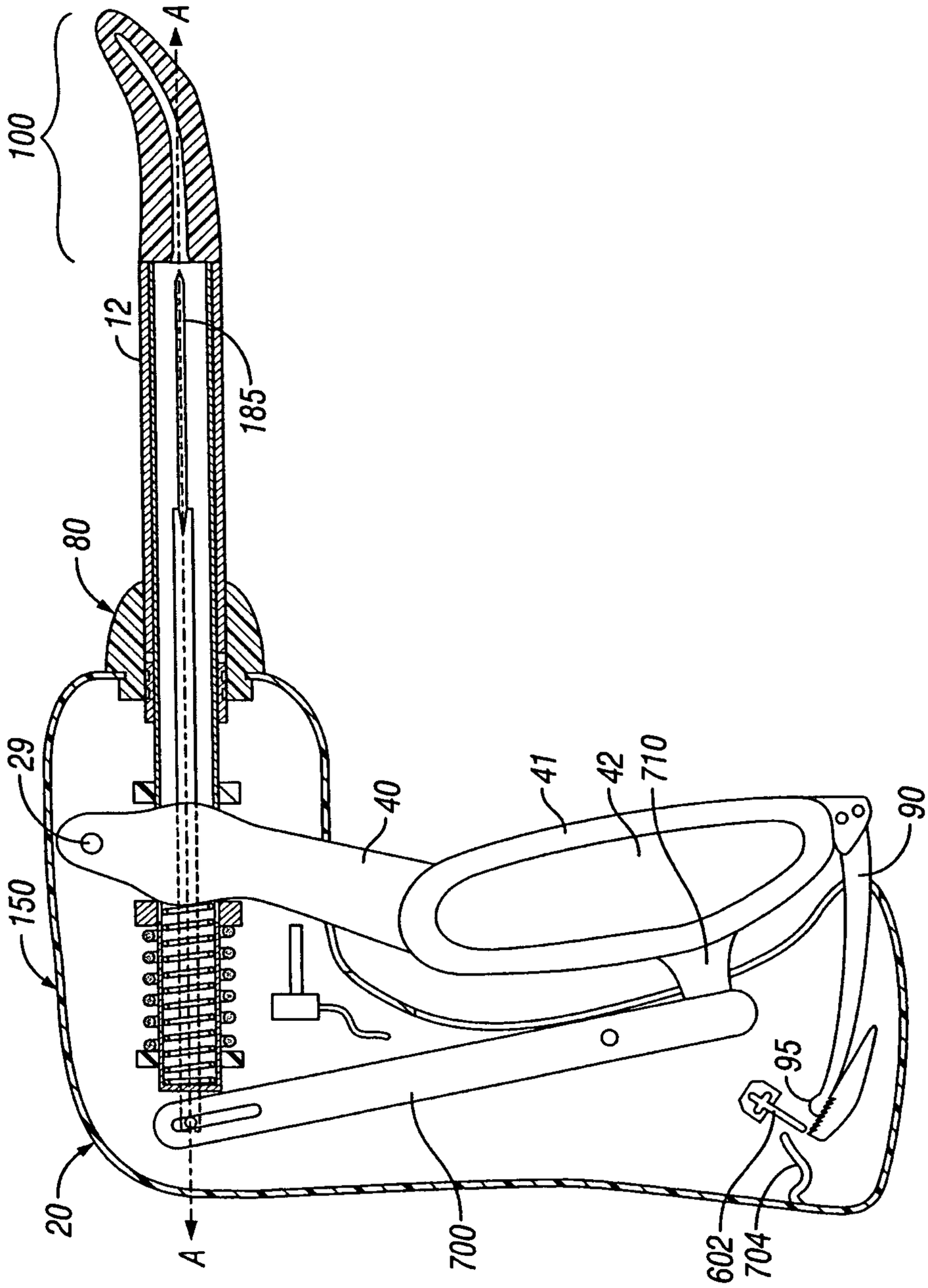
FIG. 2



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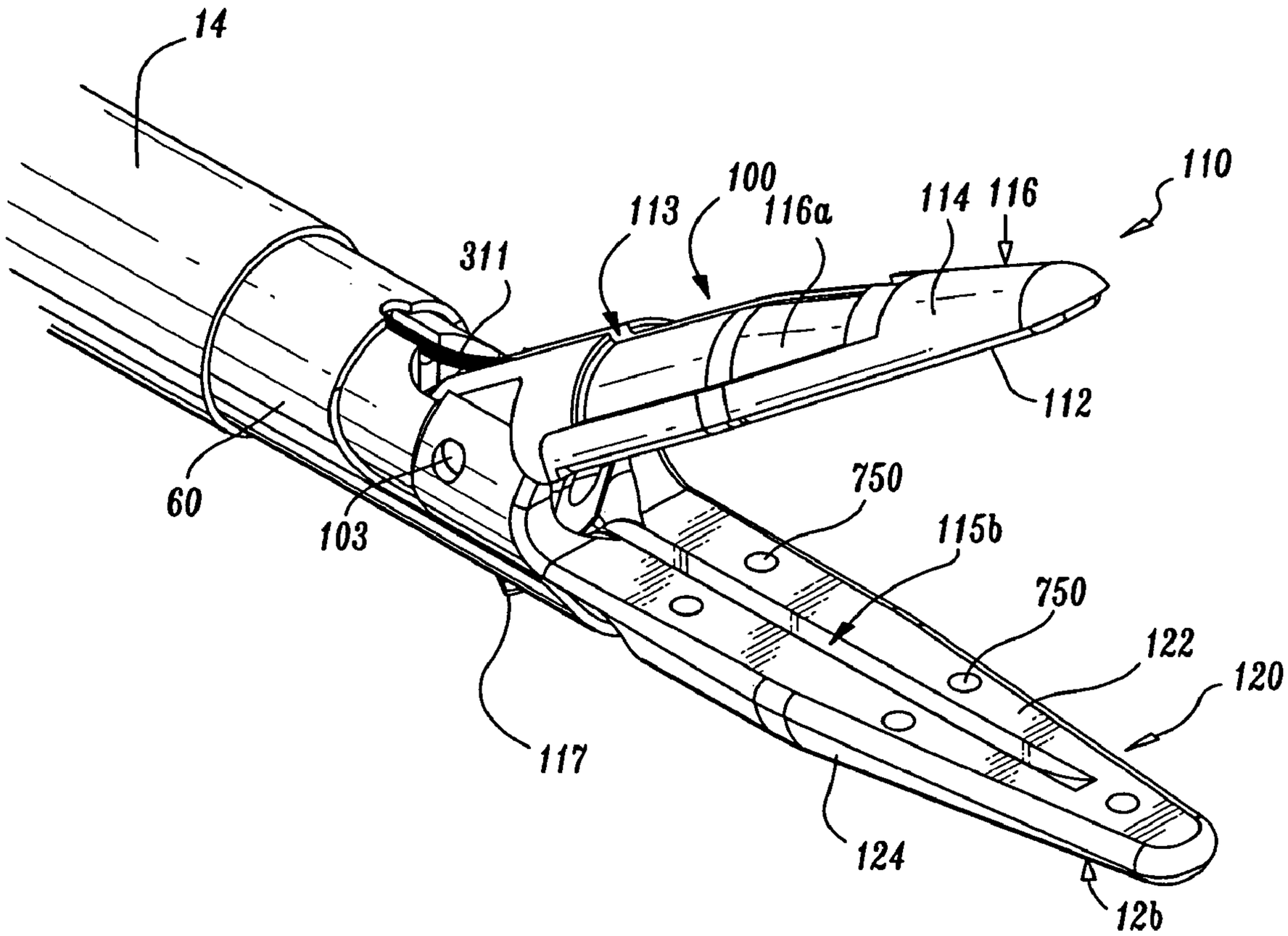
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FIG. 4

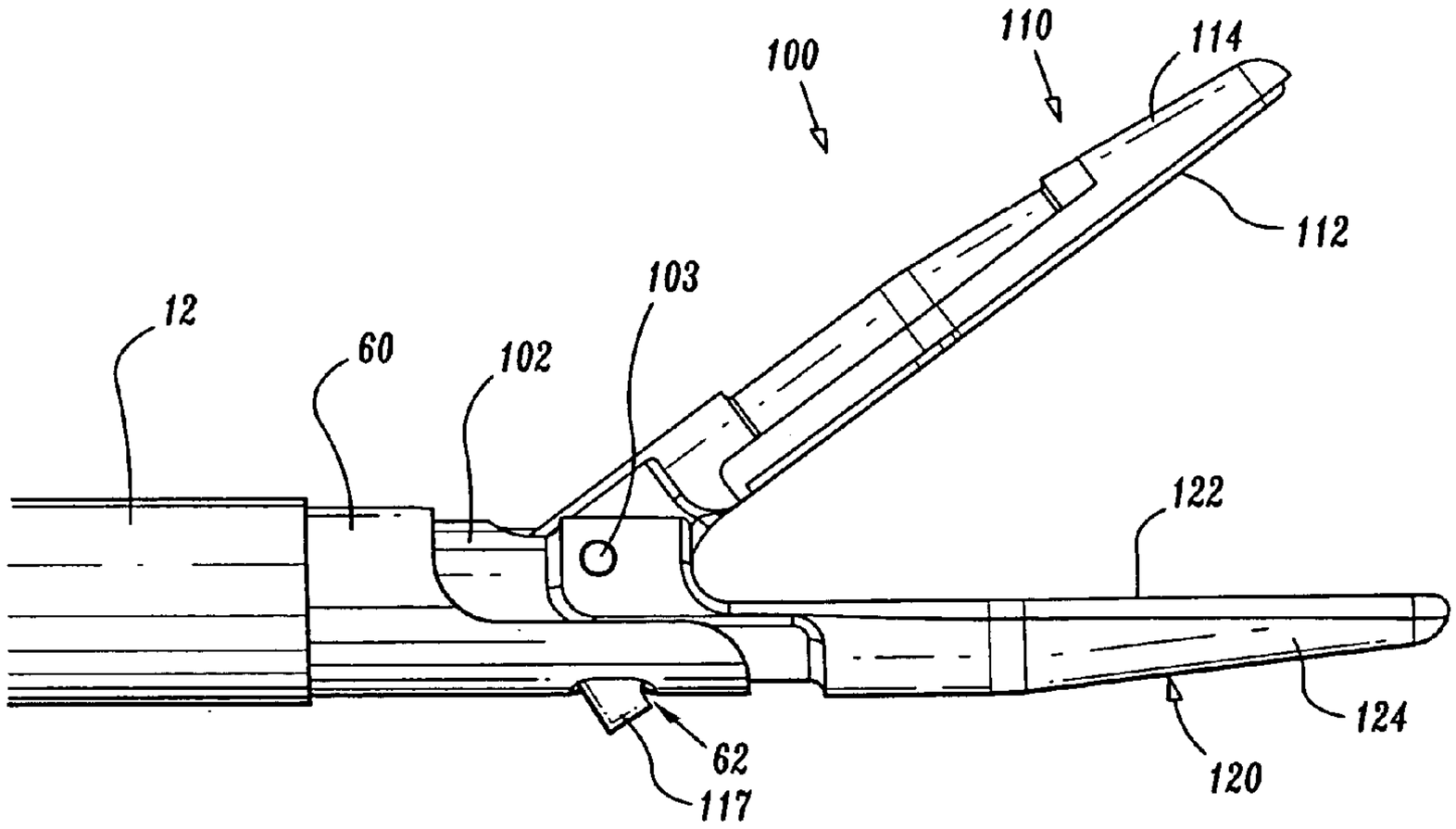
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FIG. 5

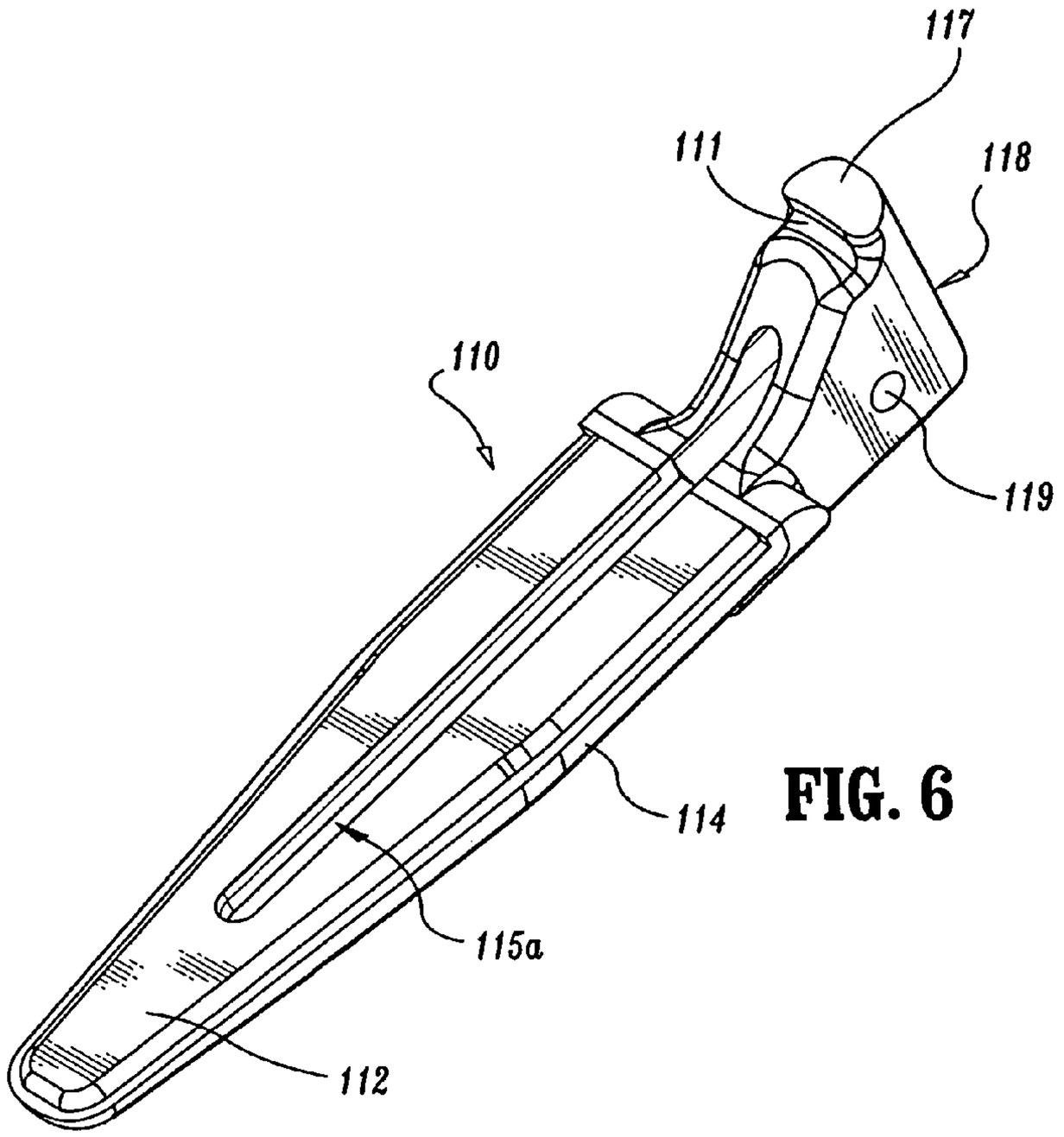
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FIG. 6

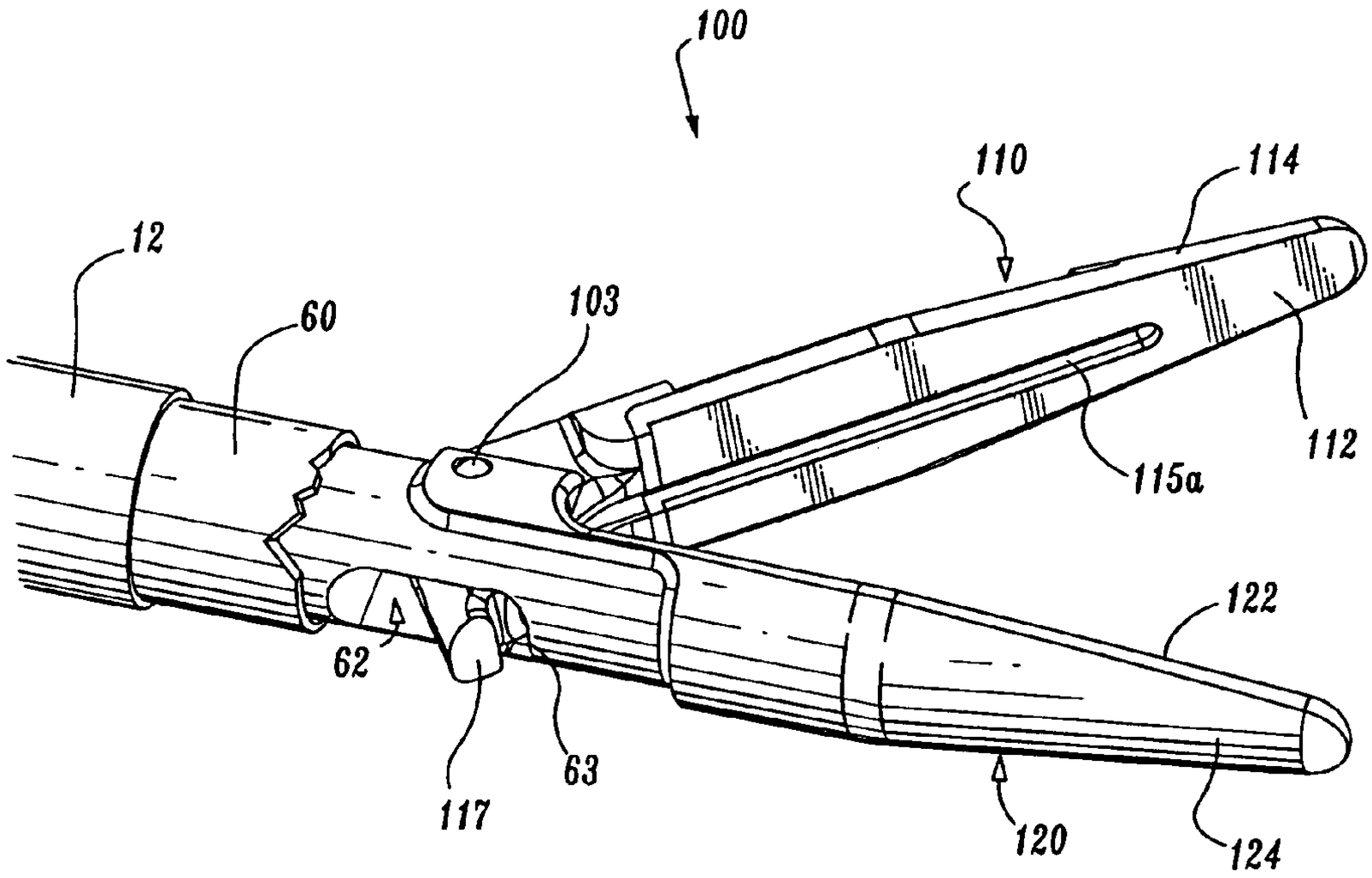
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FIG. 7

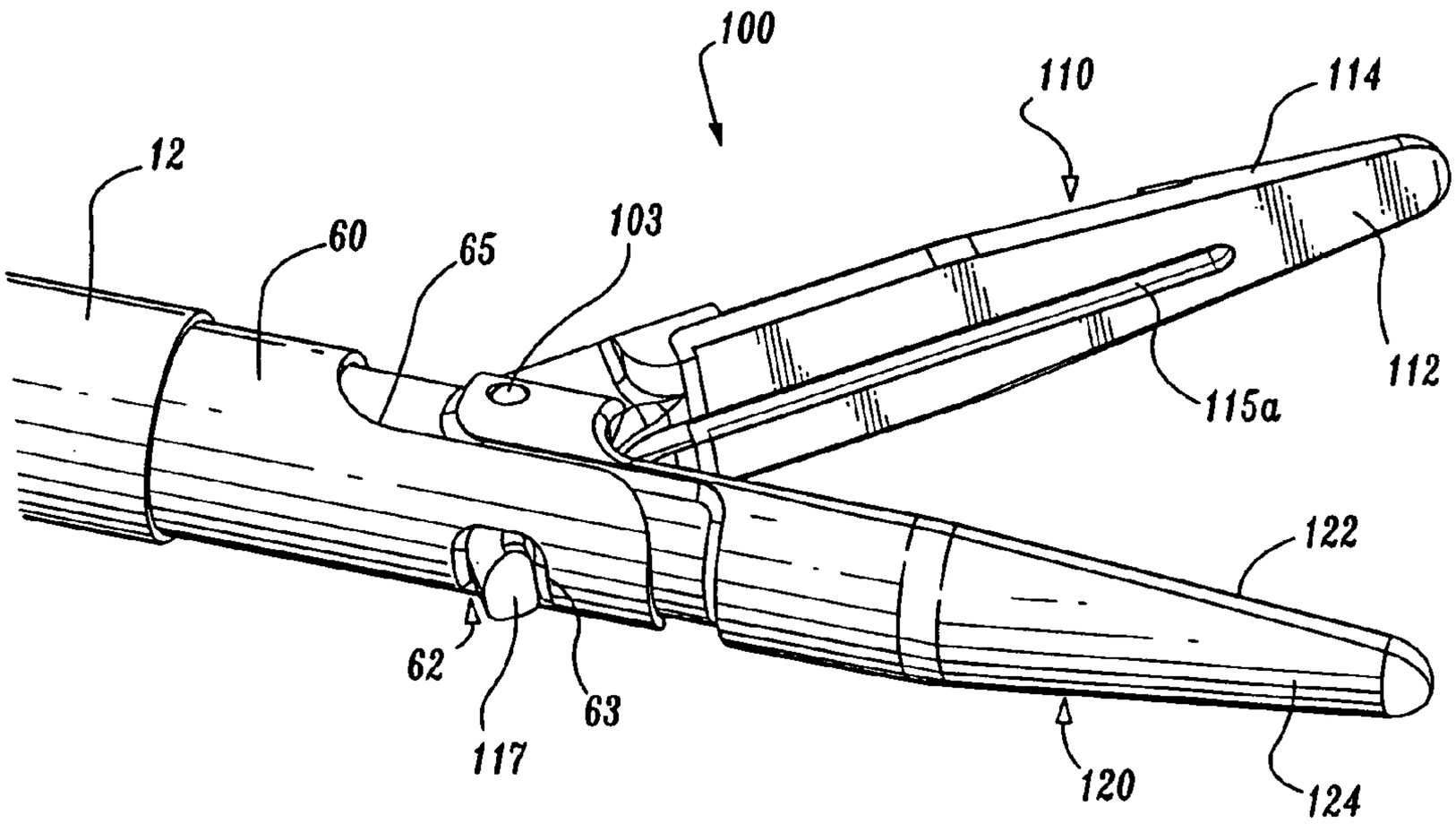
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FIG. 8

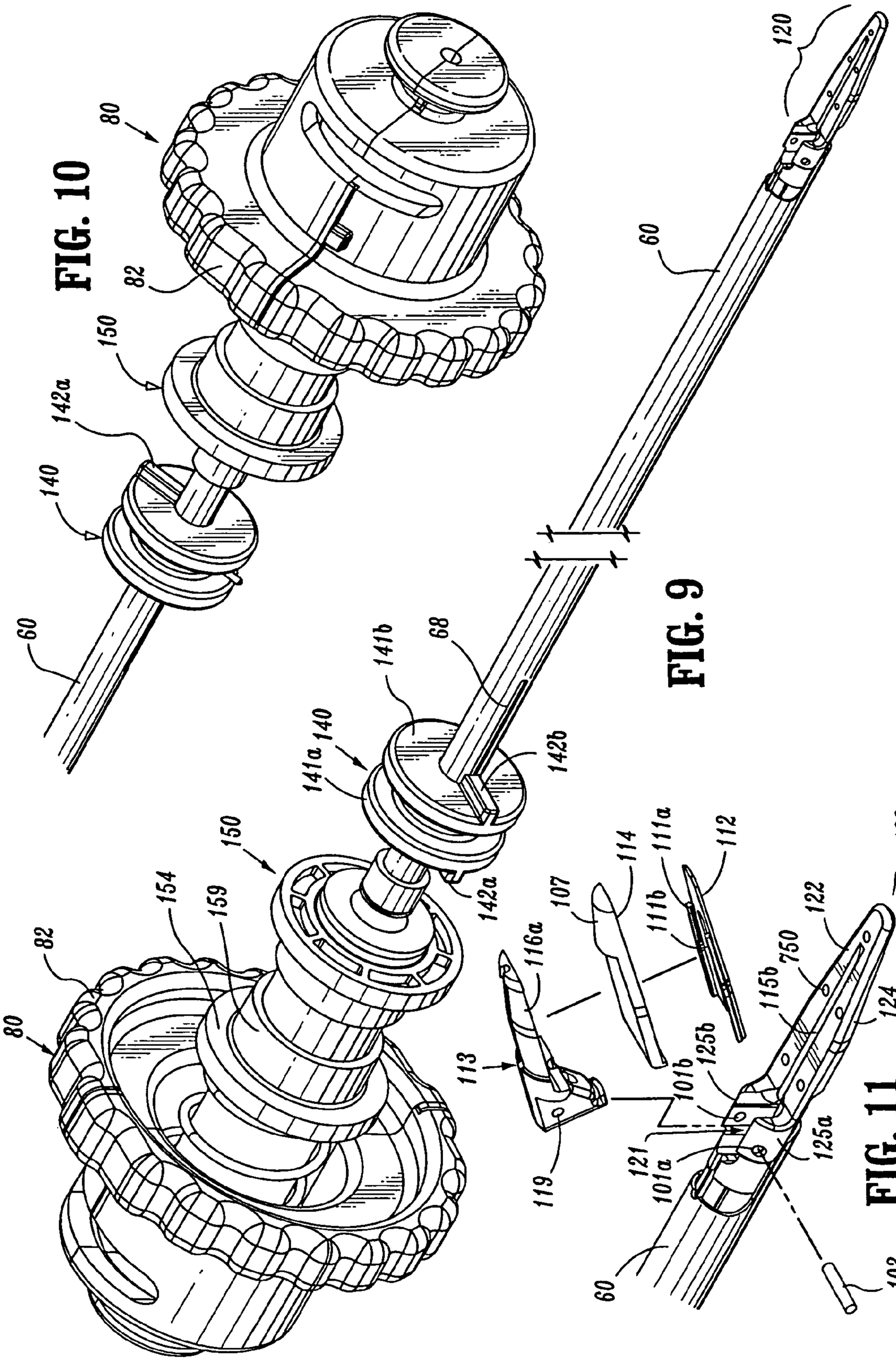
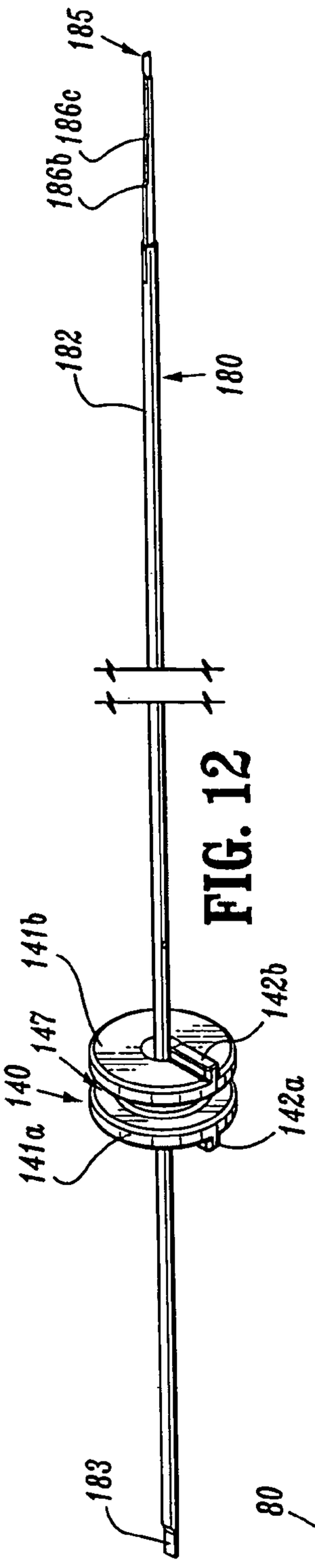


FIG. 9

FIG. 10

FIG. 11



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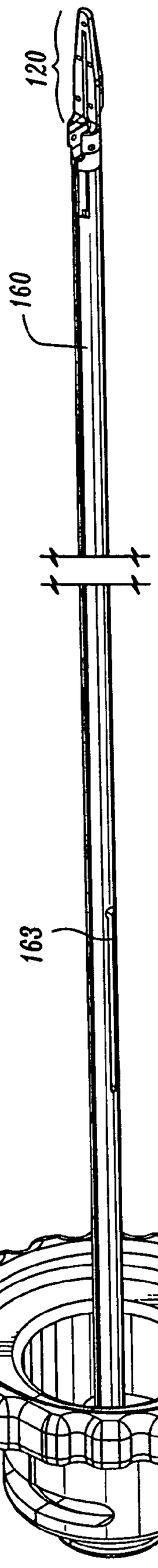

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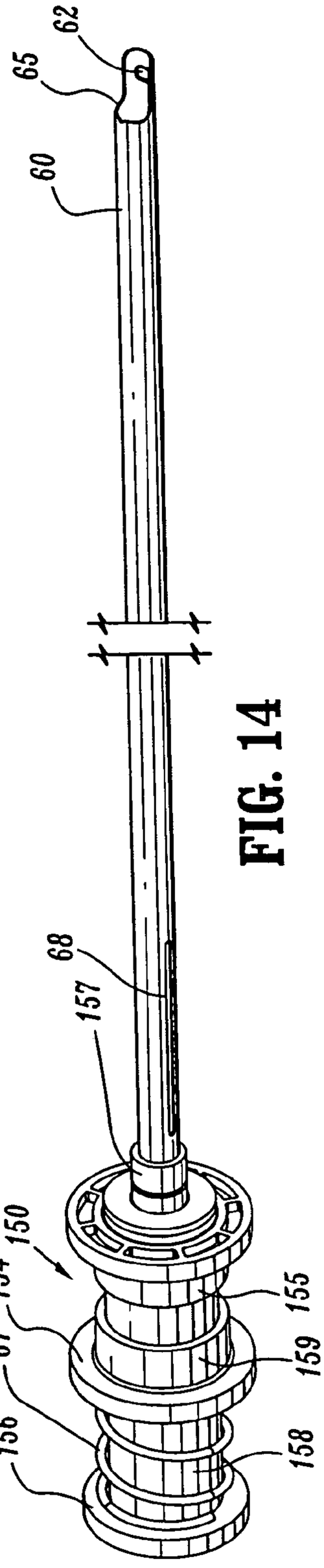

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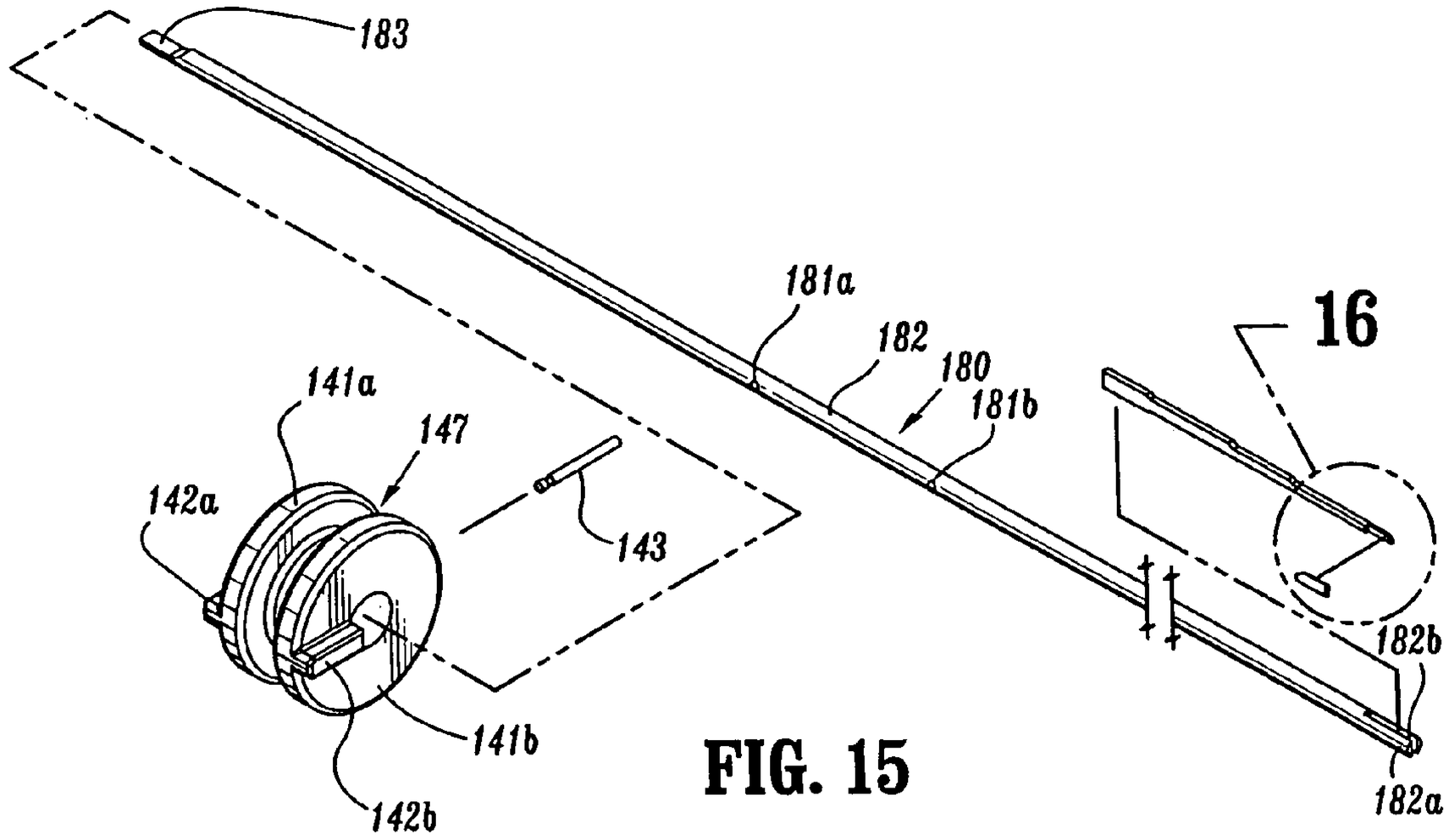

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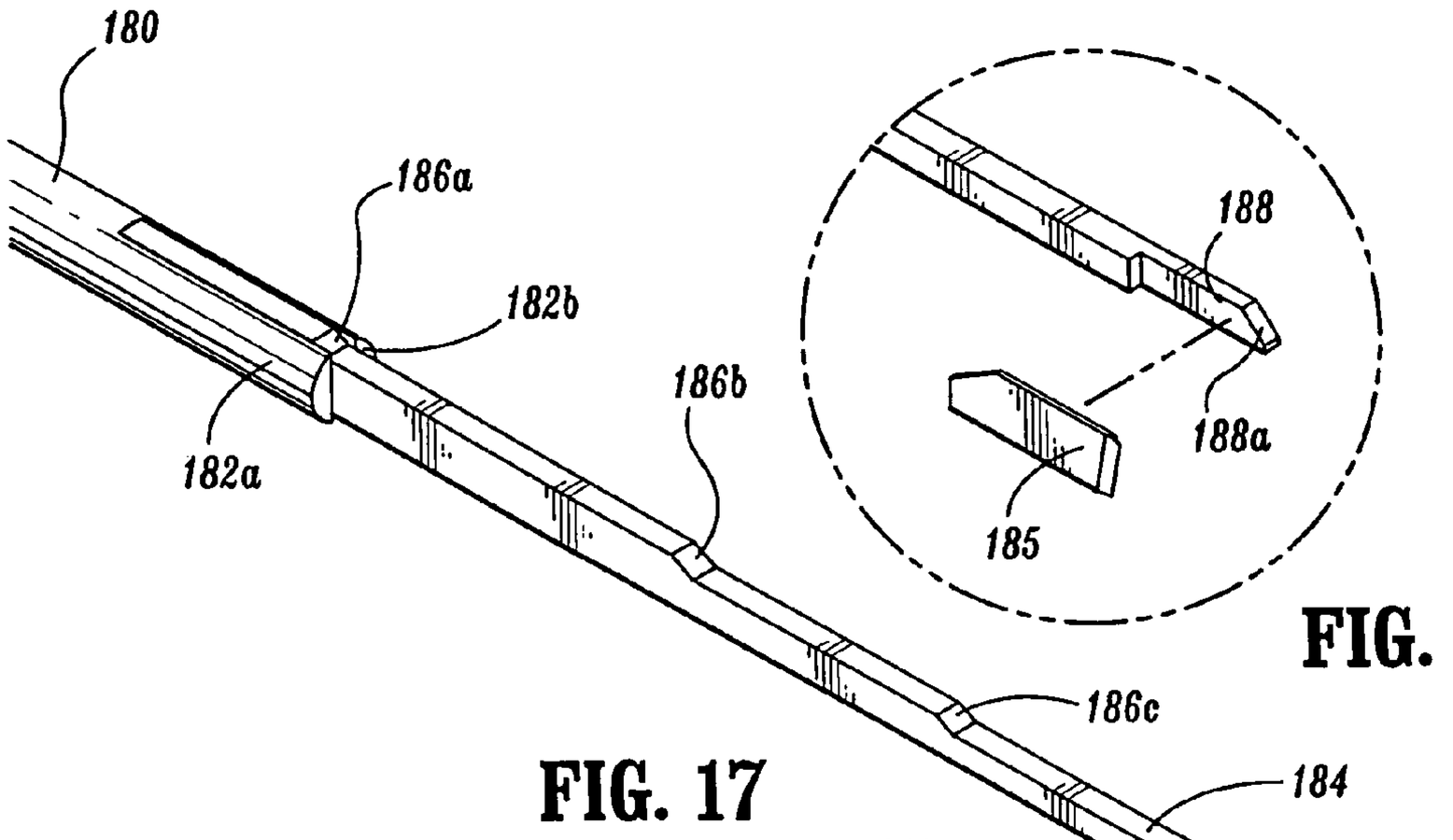
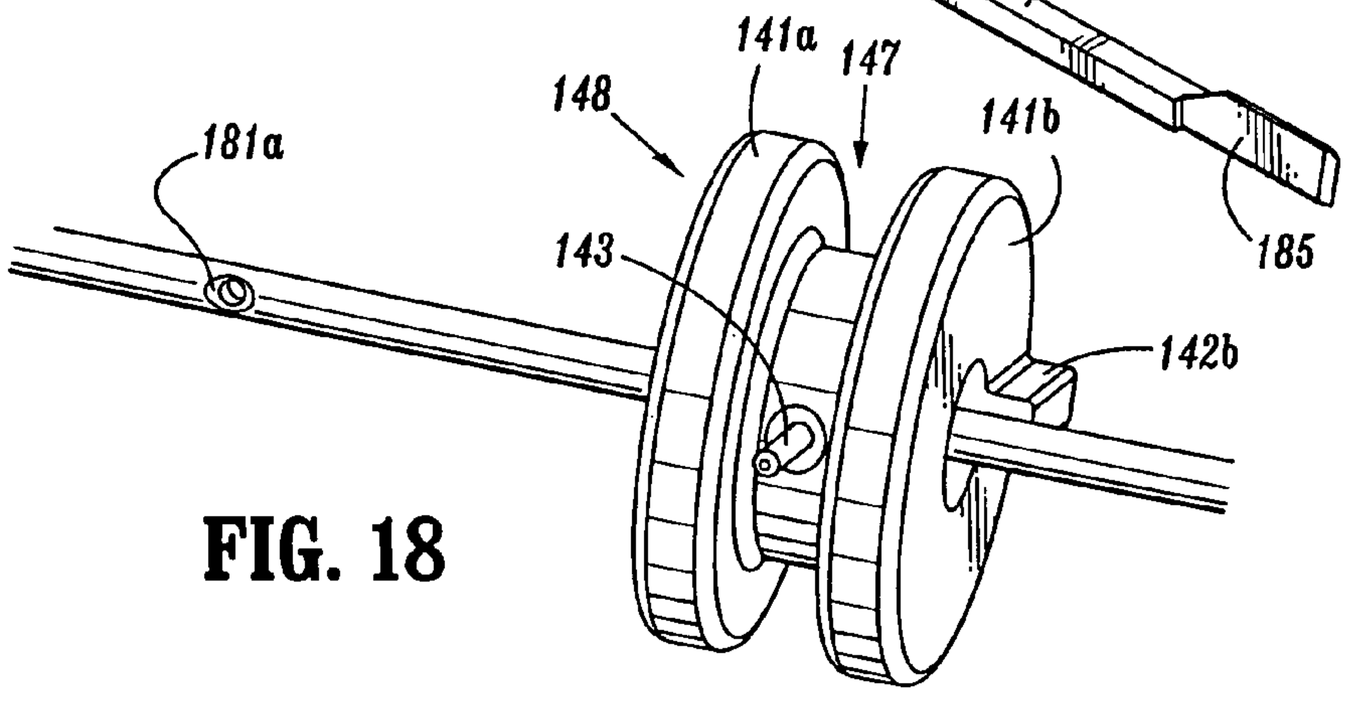


FIG. 16

FIG. 17



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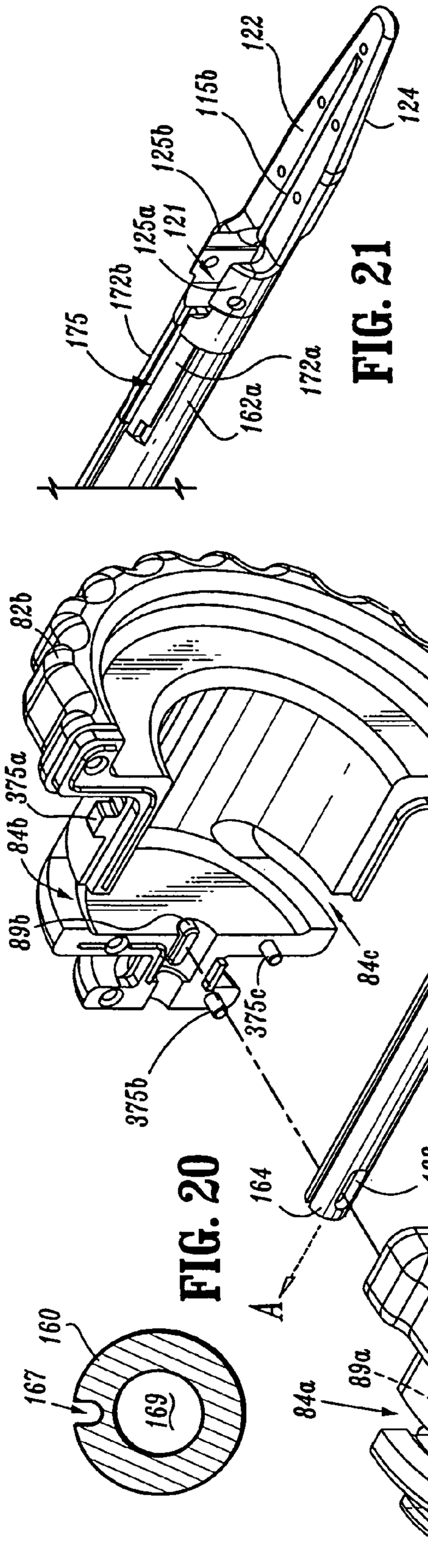

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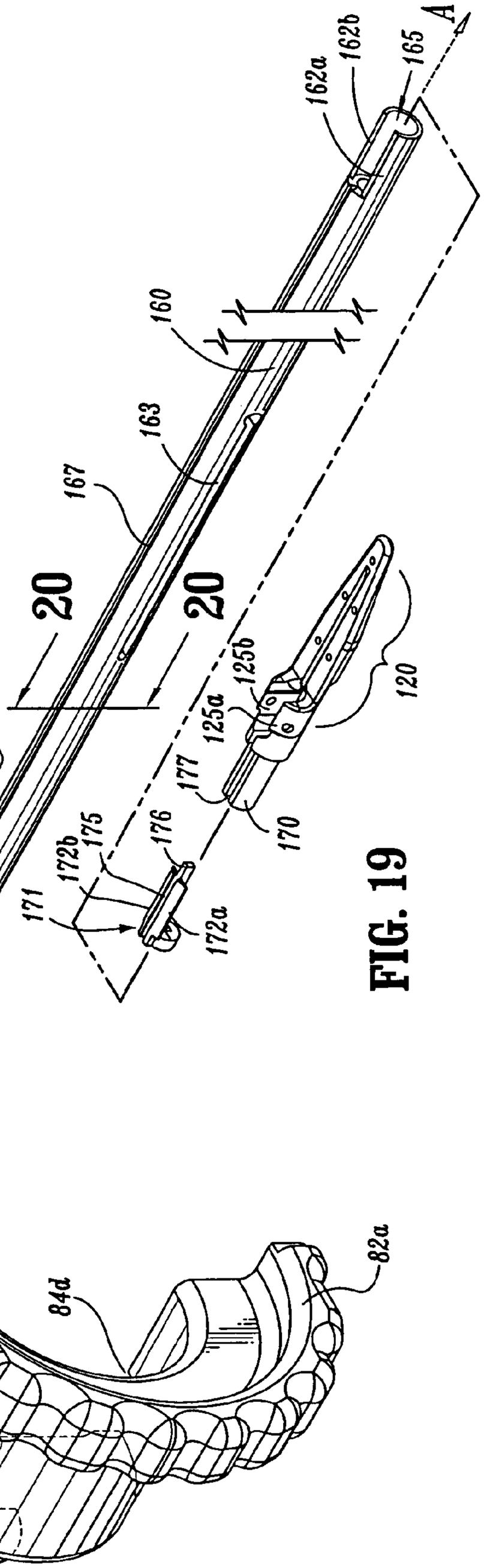

FIG. 19

FIG. 20

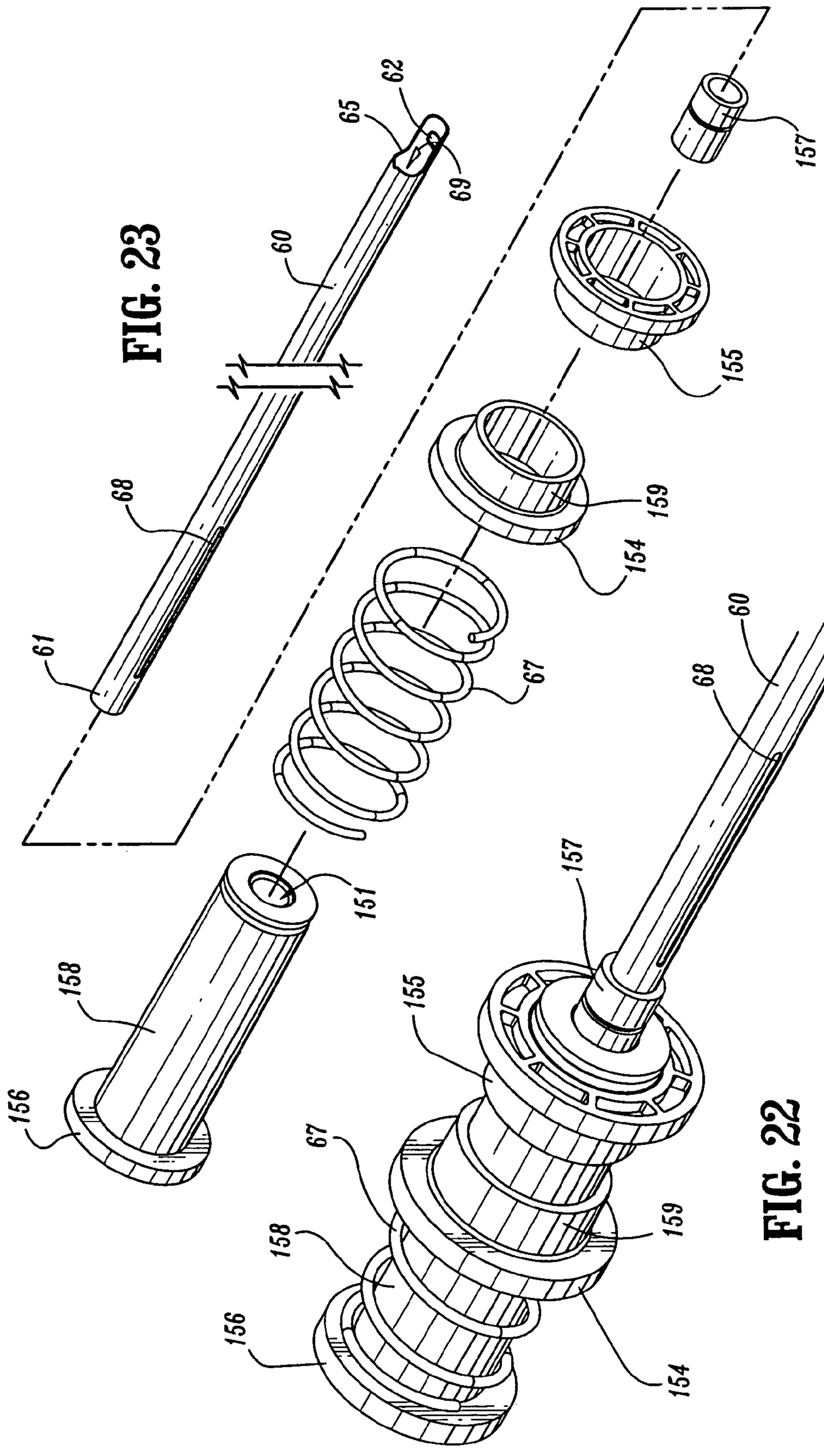
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FIG. 22

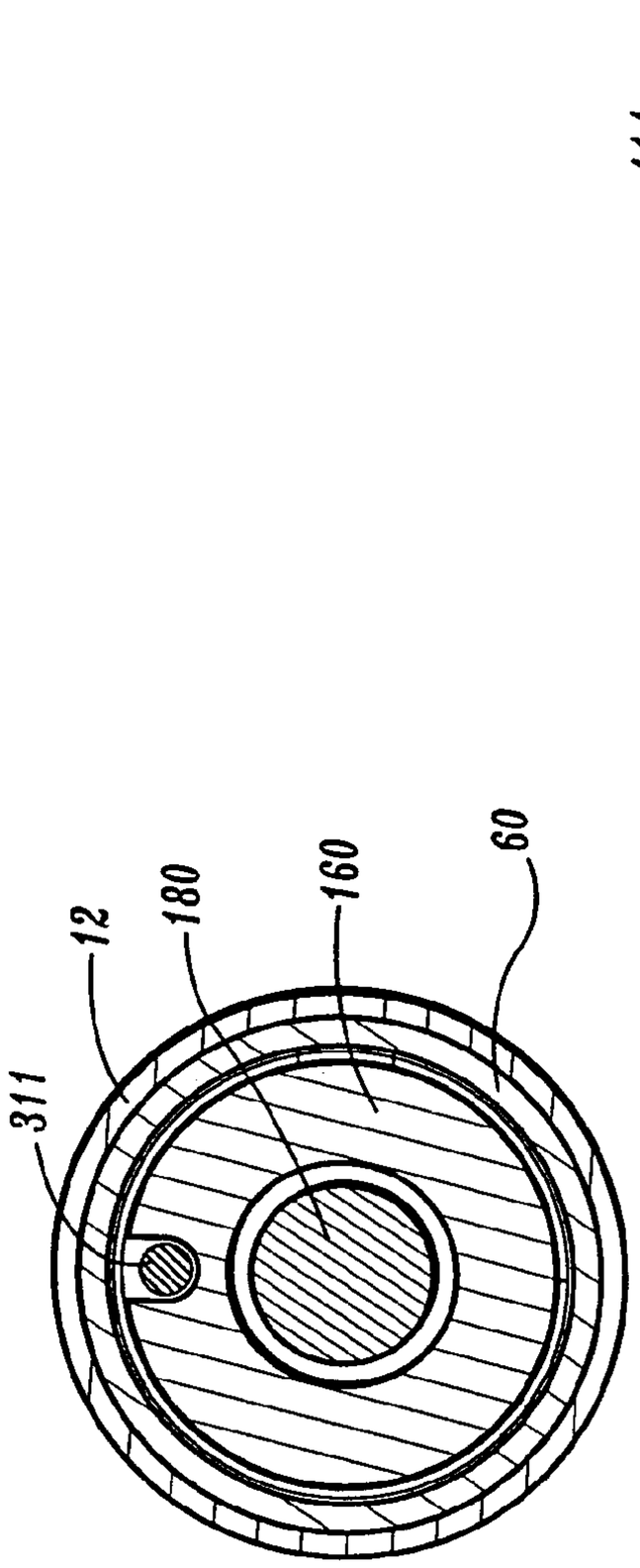
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FIG. 24

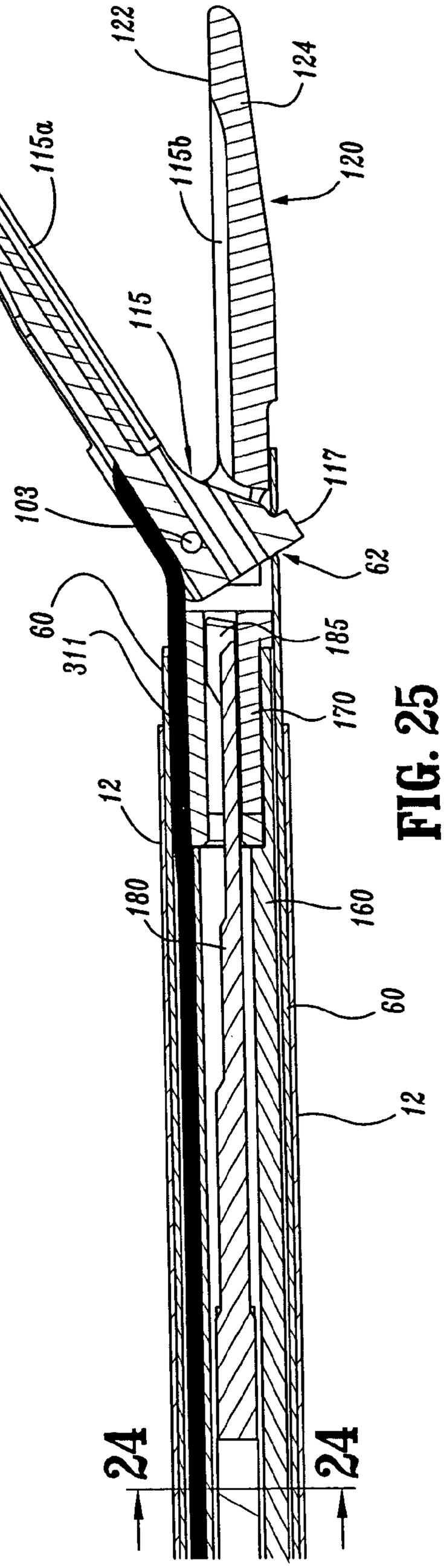
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FIG. 25

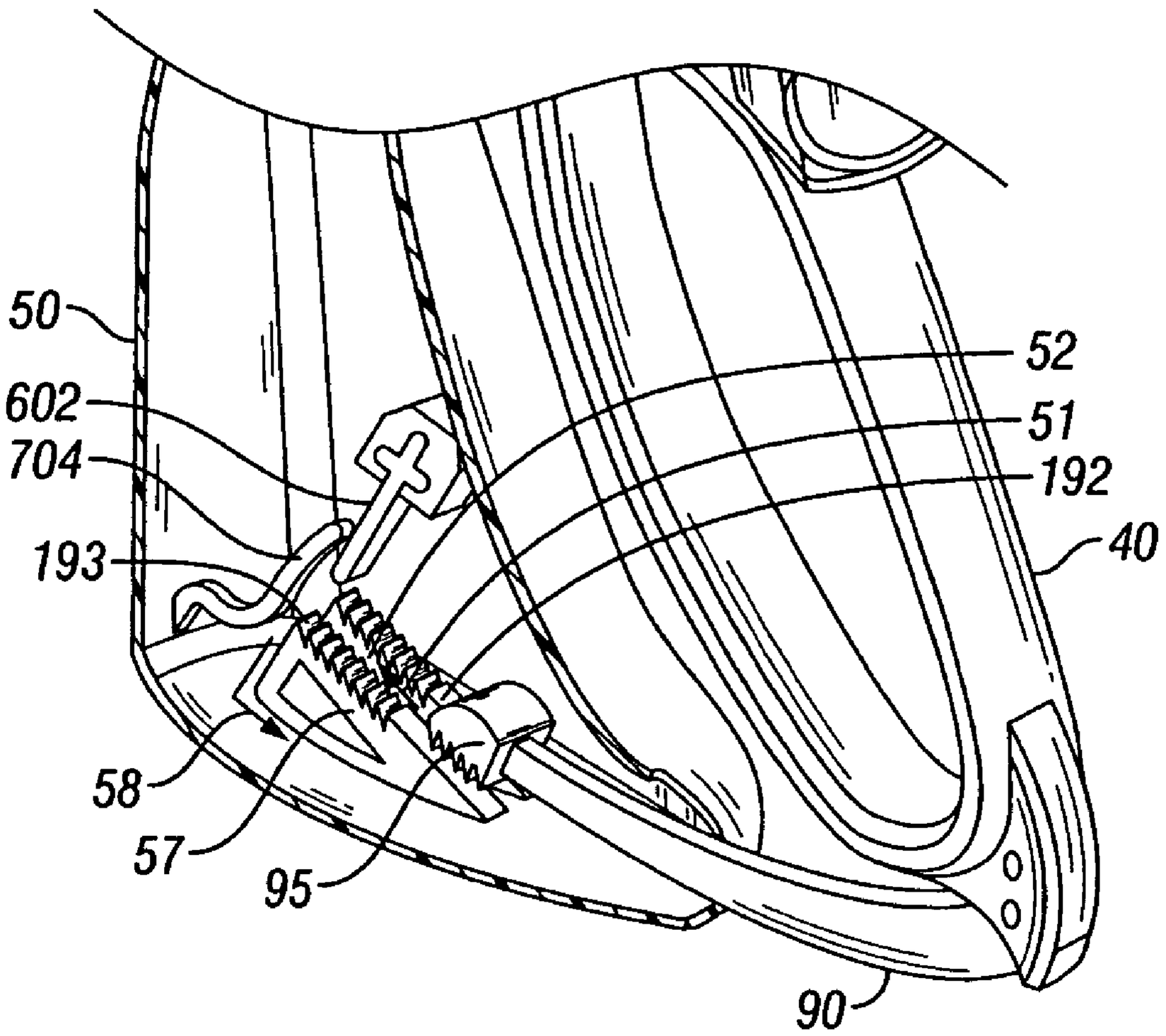
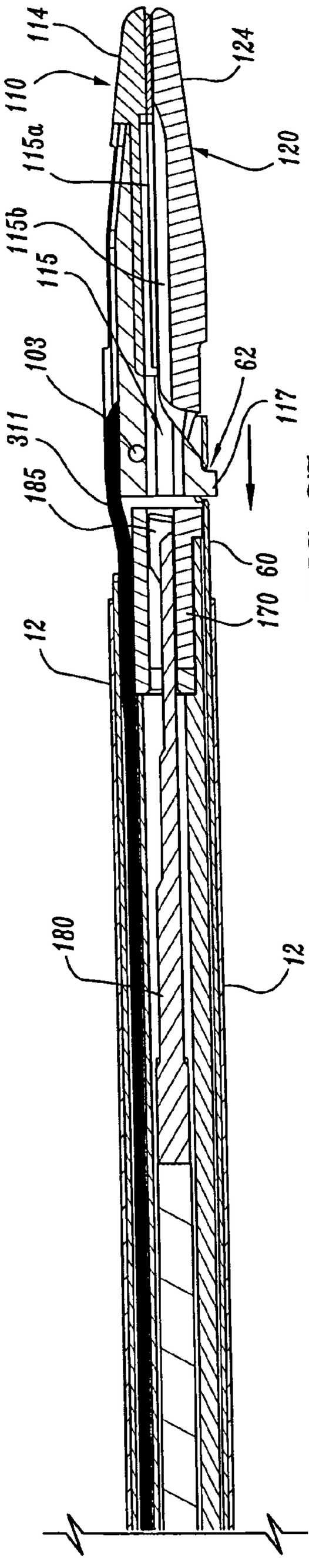


FIG. 26



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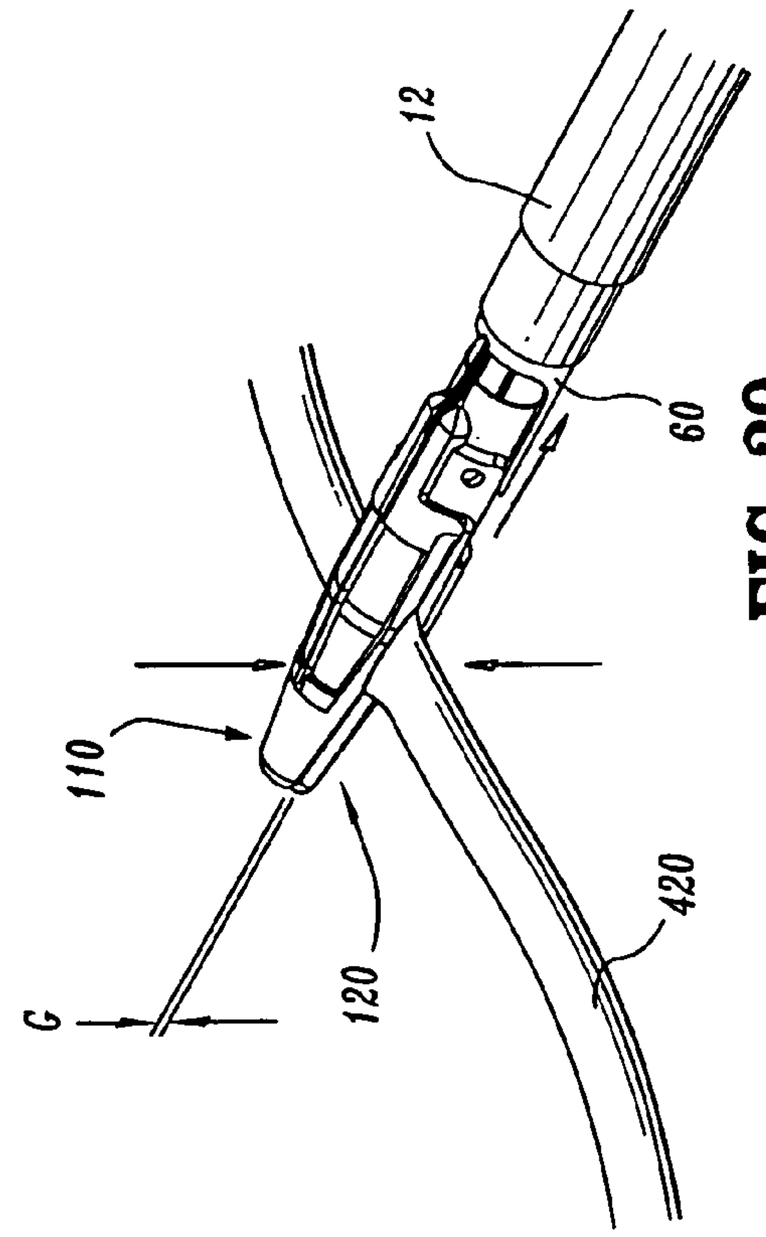

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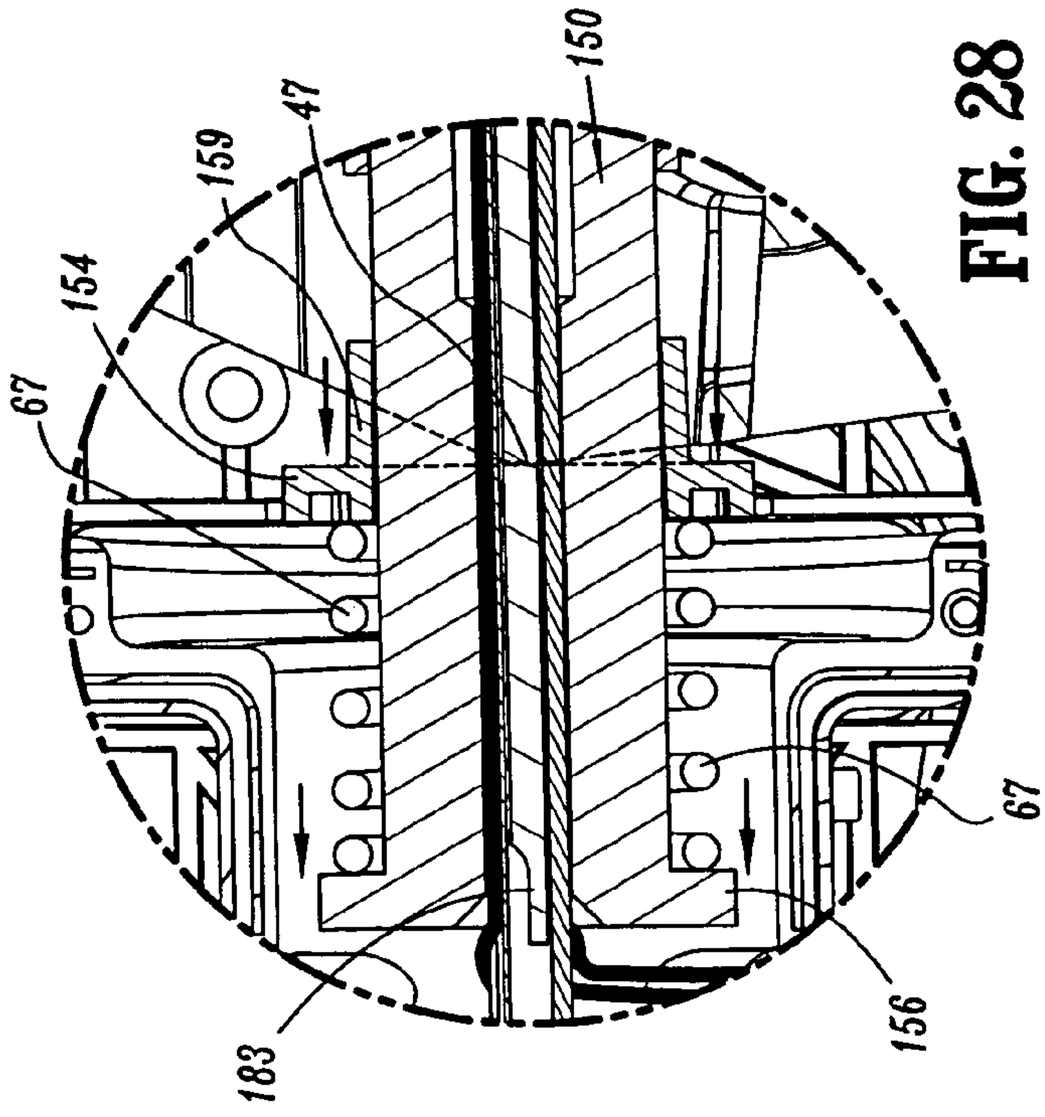
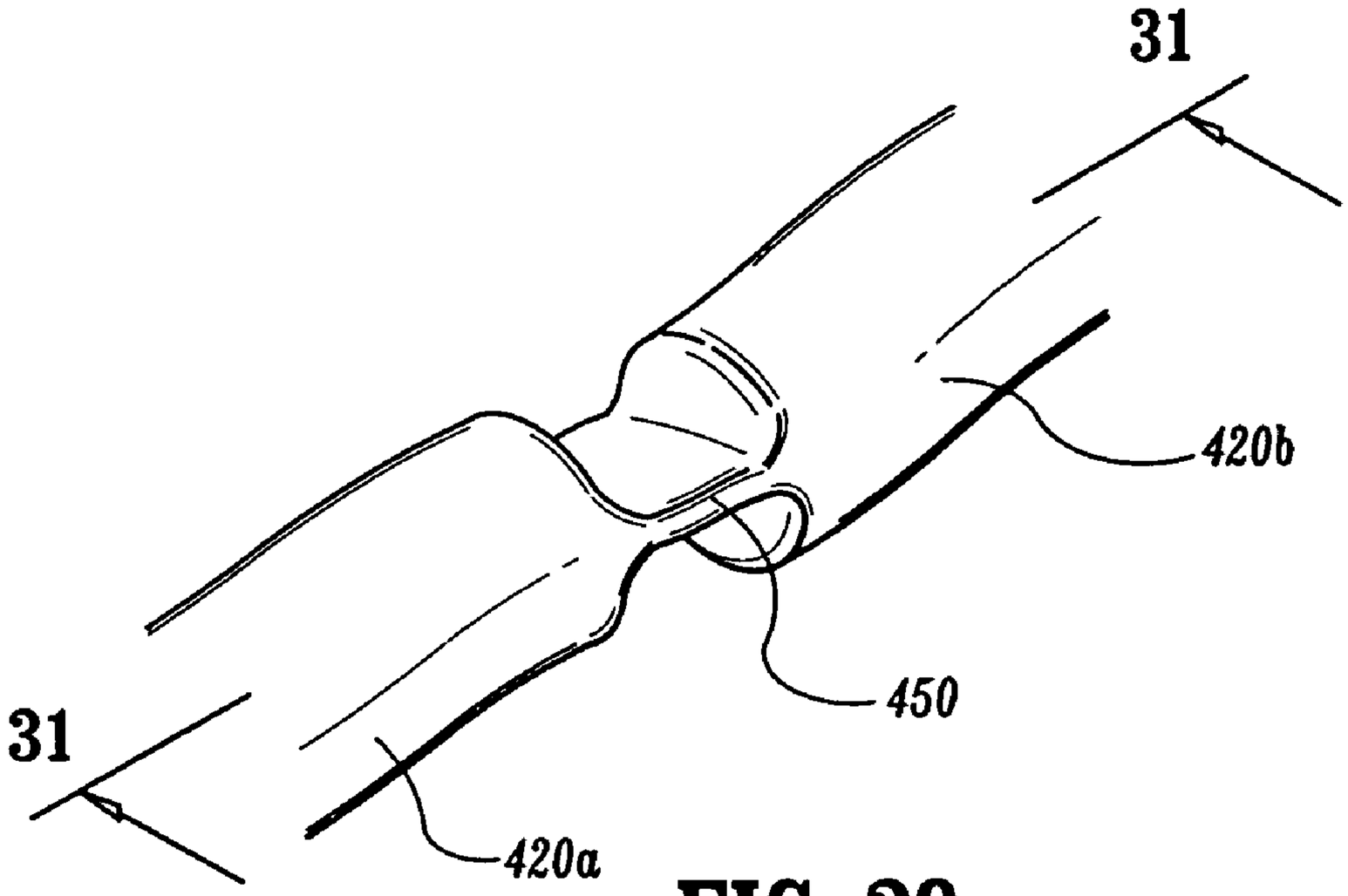


FIG. 28



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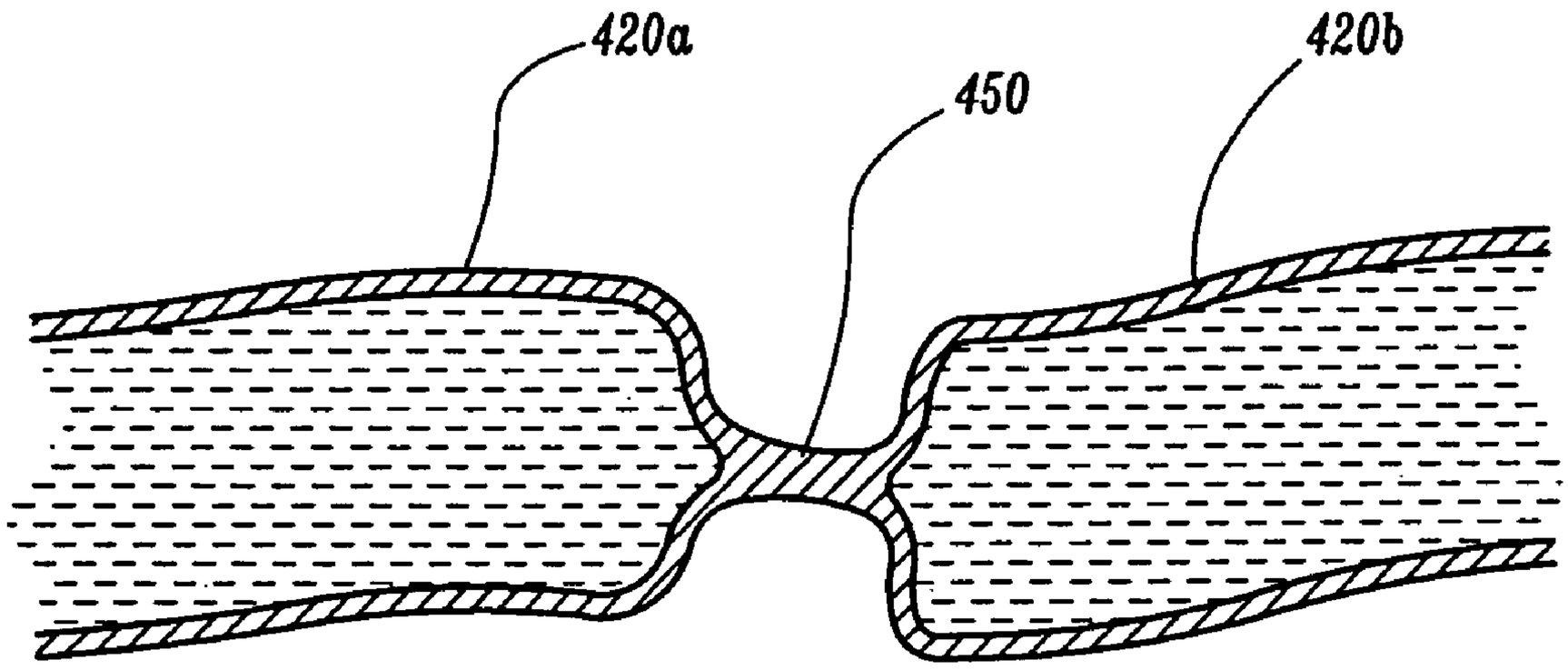

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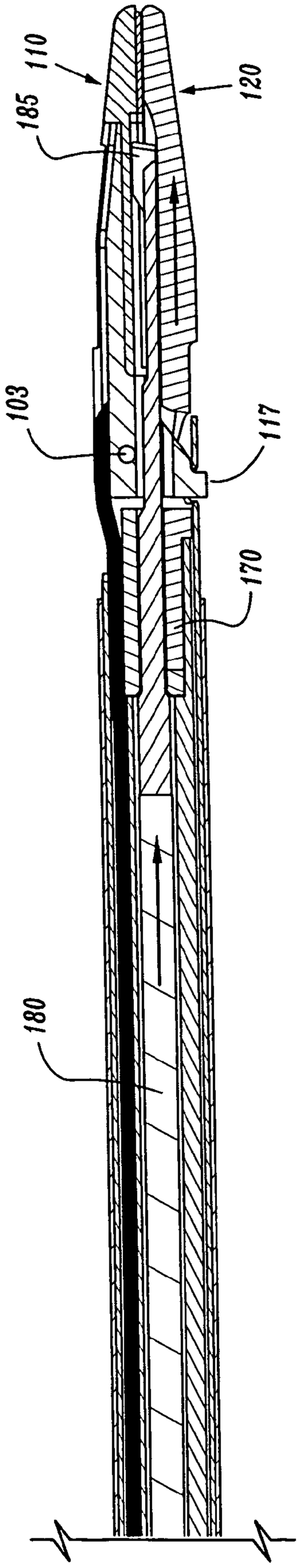

FIG. 32

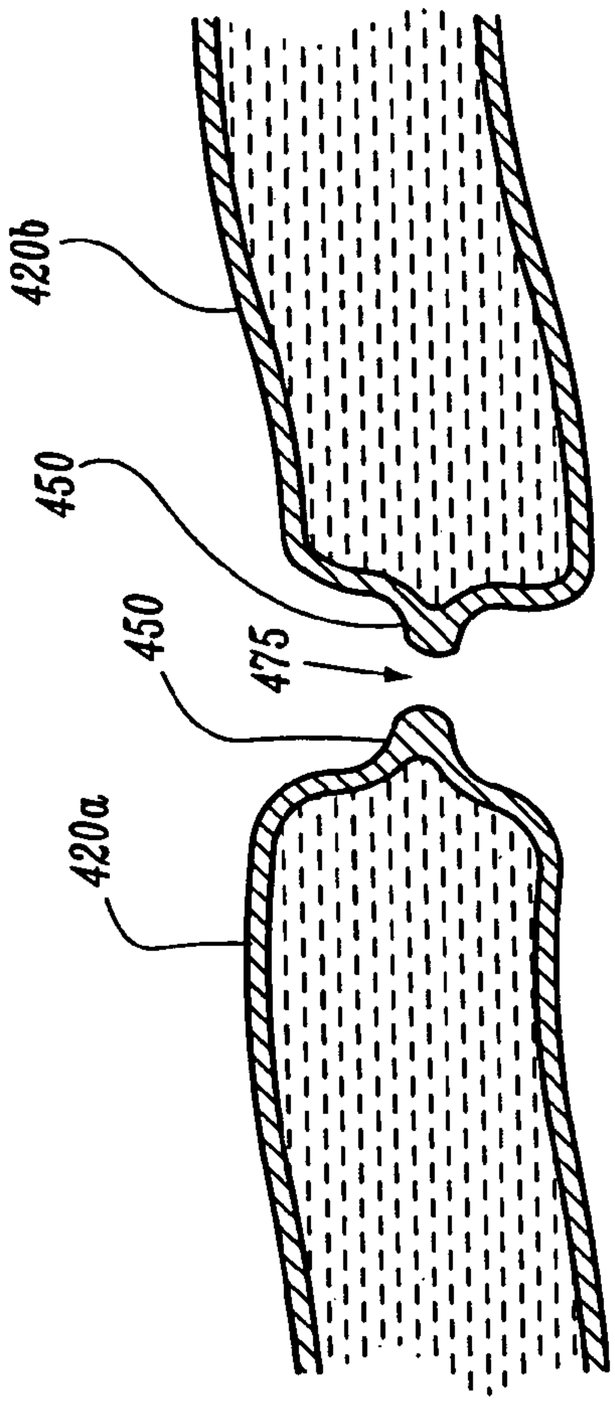

FIG. 33

SINGLE ACTION TISSUE SEALER

BACKGROUND

The present disclosure relates to an electrosurgical forceps and more particularly, the present disclosure relates to an endoscopic bipolar electrosurgical forceps for manipulating, clamping, sealing and cutting tissue in a single action.

TECHNICAL FIELD

Electrosurgical forceps utilize both mechanical clamping action and electrical energy to affect hemostasis by heating the tissue and blood vessels to coagulate, cauterize and/or seal tissue. As an alternative to open forceps for use with open surgical procedures, many modern surgeons use endoscopes and endoscopic instruments for remotely accessing organs through smaller, puncture-like incisions. As a direct result thereof, patients tend to benefit from less scarring and reduced healing time.

Endoscopic instruments are inserted into the patient through a cannula, or port, which has been made with a trocar. Typical sizes for cannulas range from about three millimeters to about 12 millimeters. Smaller cannulas are usually preferred, which, as can be appreciated, ultimately presents a design challenge to instrument manufacturers who look for ways to make endoscopic instruments that fit through the smaller cannulas.

Many endoscopic surgical procedures require cutting or ligating blood vessels or vascular tissue. Due to the inherent spatial considerations of the surgical cavity, surgeons often have difficulty suturing vessels or performing other traditional methods of controlling bleeding, e.g., clamping and/or tying-off transected blood vessels. By utilizing an endoscopic electrosurgical forceps, a surgeon can either cauterize, coagulate/desiccate and/or simply reduce or slow bleeding simply by controlling the intensity, frequency and duration of the electrosurgical energy applied through the jaw members to the tissue. Most small blood vessels, i.e., in the range below two millimeters in diameter, can often be closed using standard electrosurgical instruments and techniques. However, if a larger vessel is ligated, it may be necessary for the surgeon to convert the endoscopic procedure into an open-surgical procedure and thereby abandon the benefits of endoscopic surgery. Alternatively, the surgeon can seal the larger vessel or tissue.

It is thought that the process of coagulating vessels is fundamentally different from electrosurgical vessel sealing. For the purposes herein, "coagulation" is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dried. "Vessel sealing" or "tissue sealing" is defined as the process of liquefying the collagen in the tissue so that it reforms into a fused mass. Coagulation of small vessels is sufficient to permanently close them, while larger vessels need to be sealed to assure permanent closure.

In order to effectively seal larger vessels (or tissue) two predominant mechanical parameters should be accurately controlled—the pressure applied to the vessel (tissue) and the gap distance between the electrodes—both of which are affected by the thickness of the sealed vessel. More particularly, accurate application of pressure is important to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough electrosurgical energy through the tissue; to overcome the forces of expansion during tissue heating; and to contribute to the end tissue thickness which is an indication of a good seal. It has been determined that a typical fused vessel wall is optimum between about

0.001 and about 0.006 inches. Below this range, the seal may shred or tear and above this range the lumens may not be properly or effectively sealed.

With respect to smaller vessels, the pressure applied to the tissue tends to become less relevant whereas the gap distance between the electrically conductive surfaces becomes more significant for effective sealing. In other words, the chances of the two electrically conductive surfaces touching during activation increases as vessels become smaller.

As mentioned above, in order to properly and effectively seal larger vessels or tissue, a greater closure force between opposing jaw members is required. It is known that a large closure force between the jaws typically requires a large moment about the pivot for each jaw. This presents a design challenge because the jaw members are typically affixed with pins which are positioned to have small moment arms with respect to the pivot of each jaw member. A large force, coupled with a small moment arm, is undesirable because the large forces may shear the pins. As a result, designers compensate for these large closure forces by either designing instruments with metal pins and/or by designing instruments which at least partially offload these closure forces to reduce the chances of mechanical failure. As can be appreciated, if metal pivot pins are employed, the metal pins should be insulated to avoid the pin acting as an alternate current path between the jaw members which may prove detrimental to effective sealing.

Increasing the closure forces between electrodes may have other undesirable effects, e.g., it may cause the opposing electrodes to come into close contact with one another which may result in a short circuit and a small closure force may cause pre-mature movement of the tissue during compression and prior to activation. As a result thereof, providing an instrument which consistently provides the appropriate closure force between opposing electrodes within a preferred pressure range will enhance the chances of a successful seal. As can be appreciated, relying on a surgeon to manually provide the appropriate closure force within the appropriate range on a consistent basis would be difficult and the resultant effectiveness and quality of the seal may vary. Moreover, the overall success of creating an effective tissue seal is greatly reliant upon the user's expertise, vision, dexterity, and experience in judging the appropriate closure force to uniformly, consistently and effectively seal the vessel. In other words, the success of the seal would greatly depend upon the ultimate skill of the surgeon rather than the efficiency of the instrument.

It has been found that the pressure range for assuring a consistent and effective seal is between about 3 kg/cm^2 to about 16 kg/cm^2 and, desirably, within a working range of about 7 kg/cm^2 to about 13 kg/cm^2. Manufacturing an instrument which is capable of providing a closure pressure within this working range has been shown to be effective for sealing arteries, tissues and other vascular bundles.

Various force-actuating assemblies have been developed in the past for providing the appropriate closure forces to affect vessel sealing. For example, one such actuating assembly has been developed by Valleylab, Inc., of Boulder Colo., a division of Tyco Healthcare LP, for use with Valleylab's vessel sealing and dividing instrument commonly sold under the trademark LIGASURE ATLAS®. This assembly includes a four-bar mechanical linkage, a spring and a drive assembly which cooperate to consistently provide and maintain tissue pressures within the above working ranges. The LIGASURE ATLAS® is presently designed to fit through a 10 mm cannula and includes a bi-lateral jaw closure mechanism which is activated by a foot switch. A trigger assembly extends a knife

distally to separate the tissue along the tissue seal. A rotating mechanism is associated with distal end of the handle to allow a surgeon to selectively rotate the jaw members to facilitate grasping tissue. Co-pending U.S. application Ser. Nos. 10/179,863 and 10/116,944 and PCT Application Serial Nos. PCT/US01/01890 and PCT/7201/11340 describe in detail the operating features of the LIGASURE ATLAS® and various methods relating thereto. The contents of all of these applications are hereby incorporated by reference herein.

It would be desirous to develop an instrument that reduces the number of steps it takes to perform the tissue seal and cut. Preferably, the instrument would be able to manipulate, clamp, seal and cut tissue in a single action (e.g., by squeezing a handle).

SUMMARY

The present disclosure relates to an endoscopic bipolar forceps which includes a housing and a shaft affixed to the distal end of the housing. Preferably, the shaft includes a diameter such that the shaft is freely insertable through a trocar. The shaft also includes a longitudinal axis defined therethrough and a pair of first and second jaw members attached to a distal end thereof. The forceps includes a drive assembly for moving the first jaw member relative to the second member from a first position wherein the jaw members are disposed in spaced relation relative to each other to a second position wherein the jaw members cooperate to grasp tissue therebetween. A movable handle is included which is rotatable about a pivot located above the longitudinal axis of the shaft. Movement of the movable handle mechanically cooperates with internal components to move the jaw members from the open and closed positions, to clamp tissue, to seal tissue and to cut tissue. Advantageously, the pivot is located a fixed distance above the longitudinal axis to provide lever-like mechanical advantage to a drive flange of the drive assembly. The drive flange is located generally along the longitudinal axis. The forceps is connected to a source of electrosurgical energy which carries electrical potentials to each respective jaw member such that the jaw members are capable of conducting bipolar energy through tissue held therebetween to affect a tissue seal.

The forceps includes a switch disposed within the housing which is electromechanically connected to the energy source. Advantageously, the switch allows a user to supply bipolar energy to the jaw members to affect a tissue seal. The switch is activated by contact from a cutter lever or the movable handle itself when a user continues to compress the movable handle after the tissue has been clamped.

The forceps includes an advanceable knife assembly for cutting tissue in a forward direction along the tissue seal. The knife assembly is advanced when a user continues to compress the movable handle after the tissue has been sealed, forcing the cutter lever forward. A rotating assembly may also be included for rotating the jaw members about the longitudinal axis defined through the shaft.

In one embodiment, the movable jaw member includes a first electrical potential and the fixed jaw member includes a second electrical potential. A lead connects the movable jaw member to the first potential and a conductive tube (which is disposed through the shaft) conducts a second electrical potential to the fixed jaw member. Advantageously, the conductive tube is connected to the rotating assembly to permit selective rotation of the jaw members.

In one embodiment, the drive assembly includes a reciprocating sleeve which upon activation of the movable handle, translates atop the rotating conductive tube to move the movable jaw member relative to the fixed jaw member. In one embodiment, the movable jaw member includes a detent which extends beyond the fixed jaw member which is designed for engagement with the reciprocating sleeve such that, upon translation thereof, the movable jaw member moves relative to the fixed jaw member. Advantageously, a spring is included with the drive assembly to facilitate actuation of the movable handle and to ensure the closure force is maintained within the working range of about 3 kg/cm^2 to about 16 kg/cm^2 and, preferably, about 7 kg/cm^2 to about 13 kg/cm^2

In one embodiment, at least one of the jaw members includes a series of stop members disposed thereon for regulating the distance between the jaw members (i.e., creating a gap between the two opposing jaw members) during the sealing process. As can be appreciated, regulating the gap distance between opposing jaw members along with maintaining the closing pressure to within the above-described ranges will produce a reliable and consistent tissue seal.

The present disclosure also relates to an endoscopic bipolar forceps which includes a shaft having a movable jaw member and a fixed jaw member at a distal end thereof. The forceps also includes a drive assembly for moving the movable jaw member relative to the fixed jaw member from a first position wherein the movable jaw member is disposed in spaced relation relative to the fixed jaw member to a second position wherein the movable jaw member is closer to the fixed jaw member for manipulating tissue. A movable handle is included which actuates the drive assembly to move the movable jaw member.

The forceps connects to a source of electrosurgical energy which is conducted to each jaw member such that the jaw members are capable of conducting bipolar energy through tissue held therebetween to affect a tissue seal. Advantageously, the forceps also includes a selectively advanceable knife assembly for cutting tissue in a distal direction along the tissue seal and a stop member disposed on at least one of the jaw members for regulating the distance between jaw members during sealing.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the subject instrument are described herein with reference to the drawings wherein:

FIG. **1** is a partial schematic view of one embodiment of an endoscopic bipolar forceps having a movable thumb handle in an unactuated position according to one aspect of the present disclosure;

FIG. **2** is a partial schematic view of the forceps of FIG. **1** illustrated in a partially actuated position;

FIG. **3** is a partial schematic view of another embodiment of an endoscopic bipolar forceps having a movable finger handle illustrated in a partially actuated position;

FIG. **4** is an enlarged, perspective view of an end effector assembly with jaw members shown in an open configuration;

FIG. **5** is an enlarged, side view of the end effector assembly of FIG. **4**;

FIG. **6** is an enlarged, perspective view of the tissue contacting side of an upper jaw member of the end effector assembly;

FIG. **7** is an enlarged, broken perspective view showing the end effector assembly and highlighting a cam-like closing mechanism which cooperates with a reciprocating pull sleeve to move the jaw members relative to one another;

FIG. **8** is a full perspective view of the end effector assembly of FIG. **7**;

FIG. **9** is a left, perspective view of a rotating assembly, drive assembly, knife assembly and lower jaw member according to the present disclosure;

FIG. **10** is a rear, perspective view of the rotating assembly, drive assembly and knife assembly;

FIG. **11** is an enlarged, top, perspective view of the end effector assembly with parts separated;

FIG. **12** is an enlarged, perspective view of the knife assembly;

FIG. **13** is an enlarged, perspective view of the rotating assembly;

FIG. **14** is an enlarged, perspective view of the drive assembly;

FIG. **15** is an enlarged, perspective view of the knife assembly with parts separated;

FIG. **16** is an enlarged view of the indicated area of detail of FIG. **15**;

FIG. **17** is a greatly-enlarged, perspective view of a distal end of the knife assembly;

FIG. **18** is a greatly-enlarged, perspective view of a knife drive of the knife assembly;

FIG. **19** is an enlarged, perspective view of the rotating assembly and low jaw member with parts separated;

FIG. **20** is a cross section along line **20-20** of FIG. **19**;

FIG. **21** is a greatly-enlarged, perspective view of the lower jaw member;

FIG. **22** is an enlarged, perspective view of the drive assembly;

FIG. **23** is an enlarged perspective view of the drive assembly of FIG. **22** with parts separated;

FIG. **24** is a greatly-enlarged, cross section of the shaft taken along line **24-24** of FIG. **25**;

FIG. **25** is a side, cross section of the shaft and end effector assembly;

FIG. **26** is a greatly-enlarged, perspective view of a handle assembly and latch mechanism for use with the forceps;

FIG. **27** is a greatly-enlarged view of an end effector;

FIG. **28** is a greatly-enlarged view of the drive assembly;

FIG. **29** is an enlarged, rear, perspective view of the end effector shown grasping tissue;

FIG. **30** is an enlarged view of a tissue seal;

FIG. **31** is a side, cross section of a tissue seal taken along line **31-31** of FIG. **30**;

FIG. **32** is an enlarged view of the end effector showing distal translation of the knife; and

FIG. **33** is a side, cross section of a tissue seal after separation by the knife assembly.

DETAILED DESCRIPTION

Turning now to FIGS. **1-3**, one embodiment of an endoscopic bipolar forceps **10** is shown for use with various surgical procedures and generally includes a housing **20**, a handle assembly **30**, a rotating assembly **80**, an end effector assembly **100**, a knife assembly **140** (see FIGS. **10**, **12**, **15-18**), a drive assembly **150**, a switch **500** and a latch assembly **600** which all mutually cooperate to grasp, seal and divide tubular vessels and vascular tissue **420** (FIG. **29**). Although the majority of the figure drawings depict a bipolar forceps **10** for use in connection with endoscopic surgical procedures, the present disclosure may be used for more traditional open surgical procedures. For the purposes herein, the forceps **10** is described in terms of an endoscopic instrument, however, it is contemplated that an open version of the forceps may also include the same or similar operating components and features as described below.

Forceps **10** includes a shaft **12** which has a distal end **16** dimensioned to mechanically engage the end effector assembly **100** and a proximal end **14** which mechanically engages the housing **20**. In the drawings and in the descriptions which follow, the term "proximal," as is traditional, will refer to the end of the forceps **10** which is closer to the user, while the term "distal" will refer to the end which is farther from the user.

Forceps **10** also includes an electrosurgical cable **310** which connects the forceps **10** to a source of electrosurgical energy, e.g., a generator (not shown). Generators such as those sold by Valleylab—a division of Tyco Healthcare LP, located in Boulder, Colo. are contemplated for use as a source of electrosurgical energy, e.g., FORCE EZ™ Electrosurgical Generator, FORCE FX™ Electrosurgical Generator, FORCE IC™, FORCE 2™ Generator, SurgiStat™ II. One such system is described in commonly-owned U.S. Pat. No. 6,033,399 entitled "ELECTROSURGICAL GENERATOR WITH ADAPTIVE POWER CONTROL," the entire contents of which are hereby incorporated by reference herein. Other systems have been described in commonly-owned U.S. Pat. No. 6,187,003 entitled "BIPOLAR ELECTROSURGICAL INSTRUMENT FOR SEALING VESSELS," the entire contents of which are also incorporated by reference herein.

In one embodiment, the generator includes various safety and performance features including isolated output, independent activation of accessories. In one embodiment, the electrosurgical generator includes Valleylab's Instant Response™ technology features which provide an advanced feedback system to sense changes in tissue 200 times per second and adjust voltage and current to maintain appropriate power. The Instant Response™ technology is believed to provide one or more of the following benefits to surgical procedure:

Consistent clinical effect through all tissue types;

Reduced thermal spread and risk of collateral tissue damage;

Less need to "turn up the generator"; and

Designed for the minimally invasive environment.

Cable **310** is internally divided into cable leads (not shown) which each transmit electrosurgical energy through their respective feed paths through the forceps **10** to the end effector assembly **100**. A detailed discussion of the cable leads and their connections through the forceps **10** is described in commonly-assigned, co-pending U.S. application Ser. No. 10/460,926 entitled "VESSEL SEALER AND DIVIDER FOR USE WITH SMALL TROCARS AND CANNULAS" by Dycus et al., which is hereby incorporated by reference in its entirety herein.

Handle assembly **30** includes a fixed handle **50**, a movable handle **40**, a cutter lever **700** and a handle detent **710**. Fixed handle **50** is integrally associated with housing **20** and movable handle **40** is movable relative to fixed handle **50** as explained in more detail below with respect to the operation of the forceps **10**.

In one embodiment, rotating assembly **80** is integrally associated with the housing **20** and is rotatable approximately 180 degrees in either direction about a longitudinal axis "A" (FIGS. **1** and **3**). Details of the rotating assembly **80** are described in more detail with respect to FIGS. **9** and **10**.

Housing **20** may be formed from two housing halves (not shown) which each include a plurality of interfaces which are dimensioned to mechanically align and engage one another to form housing **20** and enclose the internal working components of forceps **10**. A detailed discussion of the housing halves and how they mechanically engage with one another is described in commonly-assigned, co-pending U.S. applica-

tion Ser. No. 10/460,926 entitled "VESSEL SEALER AND DIVIDER FOR USE WITH SMALL TROCARS AND CANNULAS" by Dycus et al., which is hereby incorporated by reference in its entirety herein.

It is envisioned that a plurality of additional interfaces (not shown) may be disposed at various points around the periphery of housing halves for ultrasonic welding purposes, e.g., energy direction/deflection points. It is also contemplated that housing halves (as well as the other components described below) may be assembled together in any fashion known in the art. For example, alignment pins, snap-like interfaces, tongue and groove interfaces, locking tabs, adhesive ports, etc. may all be utilized either alone or in combination for assembly purposes.

Rotating assembly **80** includes two halves **82***a* and **82***b* (see FIGS. **13** and **19**) which, when assembled, form the rotating assembly **80** which, in turn, houses the drive assembly **150** and the knife assembly **140**. Half **82***b* includes a series of detents/flanges **375***a*, **375***b*, **375***c* and **375***d* which are dimensioned to engage a pair of corresponding sockets or other mechanical interfaces (not shown) disposed within rotating half **82***a*. In one embodiment, movable handle **40** is of unitary construction and is operatively connected to the housing **20** and the fixed handle **50** during the assembly process.

As mentioned above, end effector assembly **100** is attached at the distal end **14** of shaft **12** and includes a pair of opposing jaw members **110** and **120**. Movable handle **40** of handle assembly **30** is in mechanical cooperation with drive assembly **150** which, together, mechanically cooperate to impart movement of the jaw members **110** and **120** from an open position wherein the jaw members **110** and **120** are disposed in spaced relation relative to one another, to a clamping or closed position wherein the jaw members **110** and **120** cooperate to grasp tissue **420** (FIG. **29**) therebetween.

It is envisioned that jaw members **110** and **120** of end effector assembly **100** may be curved (as illustrated in FIG. **3**) in order to reach specific anatomical structures and promote more consistent seals for certain procedures. For example, it is contemplated that dimensioning the jaw members **110** and **120** at an angle of about 45 degrees to about 70 degrees is preferred for accessing and sealing specific anatomical structures relevant to prostatectomies and cystectomies, e.g., the dorsal vein complex and the lateral pedicles. Other angles may be preferred for different surgical procedures. Such an end effector assembly with curved jaw members is described in commonly-assigned, co-pending U.S. application Ser. No. 10/834,764 entitled "ELECTROSURGICAL INSTRUMENT WHICH REDUCES DAMAGE TO ADJACENT TISSUE," by Dycus et al., which is hereby incorporated by reference in its entirety herein.

It is envisioned that the forceps **10** may be designed such that it is fully or partially disposable depending upon a particular purpose or to achieve a particular result. For example, end effector assembly **100** may be selectively and releasably engageable with the distal end **16** of the shaft **12** and/or the proximal end **14** of shaft **12** may be selectively and releasably engageable with the housing **20** and the handle assembly **30**. In either of these two instances, the forceps **10** would be considered "partially disposable" or "reposable," i.e., a new or different end effector assembly **100** (or end effector assembly **100** and shaft **12**) selectively replaces the old end effector assembly **100** as needed. As can be appreciated, the presently disclosed electrical connections would have to be altered to modify the instrument to a reposable forceps.

Turning now to the more detailed features of the present disclosure, movable handle **40** includes a finger loop **41** which has an aperture **42** defined therethrough which enables a user to grasp and move the movable handle **40** relative to the fixed handle **50**. FIGS. **1** and **2** illustrate a movable handle **40** with finger loop **41** designed to be grasped and moved by a thumb, while FIG. **3** illustrates a movable handle **40** with finger loop **41** designed to be grasped and moved by one or more fingers. Further, the movable handle **40** of FIGS. **1** and **2** is on the proximal side of fixed handle **50**, while the movable handle **40** of FIG. **3** is on the distal side of fixed handle **50**. Movable handle **40** may also include one or more ergonomically-enhanced gripping elements (not shown) disposed along the inner peripheral edge of aperture **42** or on fixed handle **50** which is designed to facilitate gripping of the handles **40** and **50** during activation. It is envisioned that the gripping element may include one or more protuberances, scallops and/or ribs to enhance gripping.

As best seen in FIGS. **1** and **2**, movable handle **40** is selectively moveable about a pivot point **29** from a first position (FIG. **1**) relative to fixed handle **50** to a second position (FIG. **2**) in closer proximity to the fixed handle **50** which, as explained below, imparts movement of the jaw members **110** and **120** relative to one another. It is contemplated that there may be intermediate positions between those shown in FIGS. **1** and **2**, e.g., discrete closure points which correspond to ratchet positions as discussed in more detail below. Additionally, continued movement of the moveable handle **40** towards the fixed handle **50** first engages switch **500**, which causes the tissue to be sealed, and then engages knife assembly **140**, which cuts the tissue. Operation of the forceps is discussed further below.

As best seen in FIGS. **1-3** and **26**, the lower end of the movable handle **40** includes a flange **90**. Flange **90** also includes an end **95** which rides within a predefined channel **52** (see FIG. **26**) and mechanically engages with ramps **57** disposed within fixed handle **50**. Additional features with respect to the end **95** are explained below in the detailed discussion of the operational features of the forceps **10**.

Movable handle **40** is designed to provide a distinct mechanical advantage over conventional handle assemblies due to the position of the pivot point **29** relative to the longitudinal axis "A" of the shaft **12** and the disposition of the drive assembly **150** along longitudinal axis "A." In other words, it is envisioned that by positioning the pivot point **29** above the drive assembly **150**, the user gains lever-like mechanical advantage to actuate the jaw members **110** and **120** enabling the user to close the jaw members **110** and **120** with lesser force while still generating the required forces necessary to affect a proper and effective tissue seal and to cut the tissue **420**. It is also envisioned that the unilateral design of the end effector assembly **100** will also increase mechanical advantage as explained in more detail below.

As shown best in FIGS. **4-8**, the end effector assembly **100** includes opposing jaw members **110** and **120** which cooperate to effectively grasp tissue **420** for sealing purposes. The end effector assembly **100** is designed as a unilateral assembly in this particular embodiment, i.e., jaw member **120** is fixed relative to the shaft **12** and jaw member **110** pivots about a pivot pin **103** to grasp tissue **420**. A bilateral jaw assembly is also envisioned wherein both jaw members are movable.

More particularly, the unilateral end effector assembly **100** includes one stationary or fixed jaw member **120** mounted in fixed relation to the shaft **12** and pivoting jaw member **110** mounted about a pivot pin **103** attached to the stationary jaw member **120**. A reciprocating sleeve **60** is slidingly disposed within the shaft **12** and is remotely operable by the drive assembly **150**. The pivoting jaw member **110** includes a detent or protrusion **117** which extends from jaw member **110** through an aperture **62** disposed within the reciprocating

sleeve **60** (FIG. **8**). The pivoting jaw member **110** is actuated by sliding the sleeve **60** axially within the shaft **12** such that a distal end **63** of the aperture **62** abuts against the detent **117** on the pivoting jaw member **110** (see FIGS. **7** and **8**). Pulling the sleeve **60** proximally closes the jaw members **110** and **120** about tissue **420** grasped therebetween and pushing the sleeve **60** distally opens the jaw members **110** and **120** for grasping purposes.

As best illustrated in FIGS. **4** and **6**, a knife channel **115***a* and **115***b* runs through the center of the jaw members **110** and **120**, respectively, such that a knife blade **185** from the knife assembly **140** can cut the tissue **420** grasped between the jaw members **110** and **120** when the jaw members **110** and **120** are in a closed position. More particularly, the knife blade **185** can only be advanced through the tissue **420** when the jaw members **110** and **120** are closed thus preventing accidental or premature activation of the knife blade **185** through the tissue **420**. Put simply, the knife channel **115** (made up of half channels **115***a* and **115***b*) is blocked when the jaws members **110** and **120** are opened and the knife channel **115** is aligned for distal activation when the jaw members **110** and **120** are closed (see FIGS. **25** and **27**). It is also envisioned that the unilateral end effector assembly **100** may be structured such that electrical energy can be routed through the sleeve **60** at the protrusion **117** contact point with the sleeve **60** or using a "brush" or lever (not shown) to contact the back of the moving jaw member **110** when the jaw member **110** closes. In this instance, the electrical energy would be routed through the protrusion **117** to the stationary jaw member **120**. Alternatively, a cable lead **311** may be routed to energize the stationary jaw member **120** and the other electrical potential may be conducted through the sleeve **60** and transferred to the pivoting jaw member **110** which establishes electrical continuity upon retraction of the sleeve **60**. It is envisioned that this particular envisioned embodiment will provide at least two important safety features: 1) the knife blade **185** cannot extend while the jaw members **110** and **120** are opened; and 2) electrical continuity to the jaw members **110** and **120** is made only when the jaw members are closed. The illustrated forceps **10** only includes the knife channel **115**.

As best shown in FIG. **4**, jaw member **110** also includes a jaw housing **116** which has an insulative substrate or insulator **114** and an electrically conducive surface **112**. In one embodiment, insulator **114** is dimensioned to securely engage the electrically conductive sealing surface **112**. This may be accomplished by stamping, by overmolding, by overmolding a stamped electrically conductive sealing plate and/or by overmolding a metal injection molded seal plate. For example and as shown in FIG. **11**, the electrically conductive sealing plate **112** includes a series of upwardly extending flanges **111***a* and **111***b* which are designed to matingly engage the insulator **114**. The insulator **114** includes a shoe-like interface **107** disposed at a distal end thereof which is dimensioned to engage the jaw housing **116** in a slip-fit manner. The shoe-like interface **107** may also be overmolded about the outer periphery of the jaw **110** during a manufacturing step. It is envisioned that cable lead **311** terminates within the shoe-like interface **107** at the point where cable lead **311** electrically connects to the seal plate **112** (not shown). The movable jaw member **110** also includes a wire channel **113** which is designed to guide cable lead **311** into electrical continuity with sealing plate **112**.

All of these manufacturing techniques produce jaw member **110** having an electrically conductive surface **112** which is substantially surrounded by an insulating substrate **114**. In one embodiment, the insulator **114**, electrically conductive sealing surface **112** and the outer, non-conductive jaw housing **116** are dimensioned to limit and/or reduce many of the known undesirable effects related to tissue sealing, e.g., flash-over, thermal spread and stray current dissipation. Alternatively, it is also envisioned that the jaw members **110** and **120** may be manufactured from a ceramic-like material and the electrically conductive surface(s) **112** may be coated onto the ceramic-like jaw members **110** and **120**.

Jaw member **110** includes a pivot flange **118** (FIG. **6**) which includes a protrusion **117**. Protrusion **117** extends from pivot flange **118** and includes an arcuately-shaped inner surface **111** dimensioned to matingly engage the aperture **62** of sleeve **60** upon retraction thereof. Pivot flange **118** also includes a pin slot **119** which is dimensioned to engage pivot pin **103** to allow jaw member **110** to rotate relative to jaw member **120** upon retraction of the reciprocating sleeve **60**. As explained in more detail below, pivot pin **103** also mounts to the stationary jaw member **120** through a pair of apertures **101***a* and **101***b* disposed within a proximal portion of the jaw member **120**.

It is envisioned that the electrically conductive sealing surface **112** may also include an outer peripheral edge which has a pre-defined radius and the insulator **114** meets the electrically conductive sealing surface **112** along an adjoining edge of the sealing surface **112** in a generally tangential position. In one embodiment, at the interface, the electrically conductive surface **112** is raised relative to the insulator **114**. These and other envisioned embodiments are discussed in co-pending, commonly assigned Application Serial No. PCT/US01/11412 entitled "ELECTROSURGICAL INSTRUMENT WHICH REDUCES COLLATERAL DAMAGE TO ADJACENT TISSUE" by Johnson et al. and co-pending, commonly assigned Application Serial No. PCT/US01/11411 entitled "ELECTROSURGICAL INSTRUMENT WHICH IS DESIGNED TO REDUCE THE INCIDENCE OF FLASHOVER" by Johnson et al., both of which are hereby incorporated by reference in their entirety herein.

The electrosurgical seal and/or cut can be made utilizing various electrode assemblies on the jaw members, such that energy is applied to the tissue through sealing plates. This and other envisioned electrosurgical sealing and cutting techniques are discussed in co-pending, commonly assigned application Ser. No. 10/932,612 entitled "VESSEL SEALING INSTRUMENT WITH ELECTRICAL CUTTING MECHANISM" by Johnson et al., which is hereby incorporated by reference in its entirety herein.

In one embodiment, the electrically conductive surface **112** and the insulator **114**, when assembled, form a longitudinally-oriented slot **115***a* defined therethrough for reciprocation of the knife blade **185**. It is envisioned that the knife channel **115***a* cooperates with a corresponding knife channel **115***b* defined in stationary jaw member **120** to facilitate longitudinal extension of the knife blade **185** along a preferred cutting plane to effectively and accurately separate the tissue **420** along the formed tissue seal **450** (see FIGS. **30** and **33**).

Jaw member **120** includes similar elements to jaw member **110** such as jaw housing **126** having an insulator **124** and an electrically conductive sealing surface **122** which is dimensioned to securely engage the insulator **124**. Likewise, the electrically conductive surface **122** and the insulator **124**, when assembled, include a longitudinally-oriented channel **115***a* defined therethrough for reciprocation of the knife blade **185**. As mentioned above, when the jaw members **110** and **120** are closed about tissue **420**, knife channels **115***a* and **115***b* form a complete knife channel **115** to allow longitudinal extension of the knife blade **185** in a distal fashion to sever tissue **420** along the tissue seal **450**. It is also envisioned that the knife channel **115** may be completely disposed in one of

the two jaw members, e.g., jaw member **120**, depending upon a particular purpose. It is envisioned that the fixed jaw member **120** may be assembled in a similar manner as described above with respect to jaw member **110**.

As best seen in FIG. **4**, jaw member **120** includes a series of stop members **750** disposed on the inner facing surfaces of the electrically conductive sealing surface **122** to facilitate gripping and manipulation of tissue and to define a gap "G" (FIG. **29**) between opposing jaw members **110** and **120** during sealing and cutting of tissue. It is envisioned that the series of stop members **750** may be employed on one or both jaw members **110** and **120** depending upon a particular purpose or to achieve a desired result. A detailed discussion of these and other envisioned stop members **750** as well as various manufacturing and assembling processes for attaching and/or affixing the stop members **750** to the electrically conductive sealing surfaces **112**, **122** are described in commonly-assigned, co-pending U.S. Application Serial No. PCT/US01/11413 entitled "VESSEL SEALER AND DIVIDER WITH NON-CONDUCTIVE STOP MEMBERS" by Dycus et al. which is hereby incorporated by reference in its entirety herein.

Jaw member **120** is designed to be fixed to the end of a rotating tube **160** which is part of the rotating assembly **80** such that rotation of the tube **160** will impart rotation to the end effector assembly **100** (see FIGS. **13** and **19**). Jaw member **120** includes a rear C-shaped cuff **170** having a slot **177** defined therein which is dimensioned to receive a slide pin **171**. More particularly, slide pin **171** includes a slide rail **176** which extends substantially the length thereof which is dimensioned to slide into friction-fit engagement within slot **177**. A pair of chamfered plates **172***a* and **172***b* extend generally radially from the slide rail **176** and include a radius which is substantially the same radius as the outer periphery of the rotating tube **160** such that the shaft **12** can encompass each of the same upon assembly.

As best shown in FIGS. **19** and **20**, the rotating tube **160** includes an elongated guide slot **167** disposed in an upper portion thereof which is dimensioned to carry cable lead **311** therealong. The chamfered plates **172***a* and **172***b* also form a wire channel **175** which is dimensioned to guide the cable lead **311** from the tube **160** and into the movable jaw member **110** (see FIG. **4**). Cable lead **311** carries a first electrical potential to movable jaw **110**.

As shown in FIG. **19**, the distal end of the tube **160** is generally C-shaped to include two upwardly extending flanges **162***a* and **162***b* which define a cavity **165** for receiving the proximal end of the fixed jaw member **120** inclusive of C-shaped cuff **170** and slide pin **171** (see FIG. **21**). In one embodiment, the tube cavity **165** retains and secures the jaw member **120** in a friction-fit manner, however, the jaw member **120** may be welded to the tube **160** depending upon a particular purpose. Tube **160** also includes an inner cavity **169** defined therethrough which reciprocates the knife assembly **140** upon distal activation thereof and an elongated guide rail **163** which guides the knife assembly **140** during distal activation (see FIG. **20**). The details with respect to the knife assembly are explained in more detail with respect to FIGS. **15-18**. The proximal end of tube **160** includes a laterally oriented slot **168** which is designed to interface with the rotating assembly **80** as described below.

FIG. **19** also shows the rotating assembly **80** which includes C-shaped rotating halves **82***a* and **82***b* which, when assembled about tube **160**, form a generally circular rotating member **82**. More particularly, each rotating half, e.g., **82***b*, includes a series of mechanical interfaces **375***a*, **375***b*, **375***c* and **375***d* which matingly engage a corresponding series of mechanical interfaces in the other half, e.g., **82***a*, to form rotating member **82**. Half **82***b* also includes a tab **89***b* which, together with a corresponding tab **89***a* disposed on half **82***a* (phantomly illustrated), cooperate to matingly engage slot **168** disposed on tube **160**. As can be appreciated, this permits selective rotation of the tube **160** about axis "A" by manipulating the rotating member **82** in the direction of the arrow "B" (see FIG. **2**).

As best shown in the exploded view of FIG. **11**, jaw members **110** and **120** are pivotably mounted with respect to one another such that jaw member **110** pivots in a unilateral fashion from a first open position to a second closed position for grasping and manipulating tissue **420**. More particularly, fixed jaw member **120** includes a pair of proximal, upwardly extending flanges **125***a* and **125***b* which define a cavity **121** dimensioned to receive flange **118** of movable jaw member **110** therein. As explained in detail below with respect to the operation of the jaw members **110** and **120**, proximal movement of the tube **60** engages detent **117** to pivot the jaw member **110** to a closed position.

FIGS. **1-3** show the housing **20** and the component features thereof, namely, the handle assembly **30**, the rotating assembly **80**, the knife assembly **140**, the drive assembly **150**, the switch **500**, the latch assembly **600** and a cutter lever **700**.

The housing includes two halves (constructed similarly to the halves of rotating assembly **80**, as discussed above with reference to FIG. **19**) which, when mated, form housing **20**. As can be appreciated, housing **20**, once formed, houses the various assemblies identified above which will enable a user to selectively manipulate, grasp, seal and sever tissue **420** in a single action. In one embodiment, each half of the housing includes a series of mechanical interfacing components (not shown) which align and/or mate with a corresponding series of mechanical interfaces to align the two housing halves about the inner components and assemblies. The housing halves can then be sonic welded to secure the housing halves once assembled.

The movable handle **40** includes clevis **45** which pivots about pivot point **29** to pull the reciprocating sleeve **60** along longitudinal axis "A" and force a drive flange **47** against the drive assembly **150** which, in turn, closes the jaw members **110** and **120**, as explained above. As mentioned above, the lower end of the movable handle **40** includes a flange **90** which has an end **95** which rides within a predefined channel **52** disposed within fixed handle **50** (see FIG. **26**). The arrangement of the clevis **45** and the pivot point **29** of the movable handle **40** provides a distinct mechanical advantage over conventional handle assemblies due to the position of the pivot point **29** relative to the longitudinal axis "A" of the drive flange **47**. In other words, by positioning the pivot point **29** above the drive flange **47**, the user gains lever-like mechanical advantage to actuate the jaw members **110** and **120**. This reduces the overall amount of mechanical force necessary to close the jaw members **110** and **120** to affect a tissue seal.

Movable handle **40** also includes a finger loop **41** which defines opening **42** which is dimensioned to facilitate grasping the movable handle **40**. In one embodiment, finger loop **41** includes rubber insert which enhances the overall ergonomic "feel" of the movable handle **40**.

Handle assembly **30** further includes a cutter lever **700** positioned within housing **20**. When movable handle **40** is actuated (squeezed) past a certain threshold, a switch lever **502** is depressed by movable handle **40** to initiate a tissue seal cycle. A flexible detent **602** provides tactile feedback that the movable handle **40** is nearing an exit of the latch sealing zone and an end of the ramps **57**. When the movable handle **40** is pushed past the flexible detent **602**, end **95** of flange **90** drops down from ramps **57** and the user is able to return the movable

handle **40** proximally to open the jaw members **110**, **120** without cutting the seal. The user may also close the movable handle **40** to cut the sealed tissue **420** via actuation of the lever **700**. When closing movable handle **40** farther to cut tissue, end **95** contacts a latch spring **704**, which provides resistance on the movable handle **40**. This provides an indication to the user that tissue cutting is about to begin.

The movable handle **40** or a handle detent **710** contacts the cutter lever **700**, which activates knife assembly **140**, which severs the tissue **420**. As can be appreciated, this prevents accidental or premature severing of tissue **420** prior to completion of the tissue seal **450**. The generator may provide an audible signal or other type of feedback when the seal cycle is complete. The surgeon can then safely cut the seal or return the movable handle **40** without cutting. In an alternative method, an electromechanical, mechanical or electrical feature could prevent cutting without initially sealing or without the surgeon activating a special over-ride feature.

Fixed handle **50** includes a channel **52** (FIG. **26**) defined therein which is dimensioned to receive end **95** of flange **90** when movable handle **40** is actuated. The end **95** of flange **90** is dimensioned for facile reception with ramps **57** within channel **52** of fixed handle **50**. It is envisioned that flange **90** may be dimensioned to allow a user to selectively, progressively and/or incrementally move jaw members **110** and **120** relative to one another from the open to closed positions. For example, it is contemplated that end **95** and ramps **57** may include a ratchet-like interface (FIGS. **1-3**) which lockingly engages the movable handle **40** and, therefore, jaw members **110** and **120** at selective, incremental positions relative to one another depending upon a particular purpose. Such a ratchet-like interface can also prevent the movable handle **40** from becoming unactuated prior to the severing of tissue **420**.

It is also contemplated that the ratchet-like interface between the end **95** and ramps **57** are configured such that a catch basin is disposed between each step of the ratchet. A catch basin is described in commonly-assigned, co-pending U.S. application Ser. No. 10/460,926 entitled "VESSEL SEALER AND DIVIDER FOR USE WITH SMALL TROCARS AND CANNULAS" by Dycus et al., which is hereby incorporated by reference in its entirety herein, and can be utilized to be a stopping point between each of the functions that the movable handle **40** can control (i.e., manipulation, clamping, sealing and cutting). Employing such a catch basin will enable the user to selectively advance the movable handle **40**, while ensuring the functions are carried out in the proper order.

Other mechanisms may also be employed to control and/or limit the movement of movable handle **40** relative to fixed handle **50** (and jaw members **110** and **120**) such as, e.g., hydraulic, semi-hydraulic, linear actuator(s), gas-assisted mechanisms and/or gearing systems.

In one embodiment, forceps **10** includes at least one tactile element which provides tactile feedback to the user to signify when tissue is being grasped, when the tissue has been sealed and/or when the tissue has been cut. Such a tactile element may include the turning on/off of lights (not shown) on housing **20** or mechanical vibrations being created in the fixed handle **50** or movable handle **40**. It is further envisioned for a sensor to be disposed on or within forceps **10** to alert to the user when one or more completion stages has occurred, i.e., at the completion of tissue grasping, tissue sealing and/or tissue cutting.

As best illustrated in FIG. **26**, housing halves form an internal cavity which predefines the channel **52** within fixed handle **50** such that an entrance pathway **51** and an exit pathway **58** are formed for reciprocation of the end **95** of flange **90** therein. When assembled, two ramps **57** are positioned to define a rail or track **192**, such that the flange **90** can fit between the ramps **57** and end **95** moves along the track **192**. During movement of end **95** of flange **90** along the entrance and exit pathways **51** and **58**, respectively, the end **95** rides along track **192** according to the particular dimensions of the ramps **57**, which, as can be appreciated, predetermines part of the overall pivoting motion of movable handle **40** relative to fixed handle **50**.

As best illustrated in FIGS. **1** and **2**, once actuated, movable handle **40** moves in a generally arcuate fashion towards fixed handle **50** about pivot point **29**. End **95** of flange **90** moves along ramps **57** (shown as a single ramp in FIGS. **1-3** for clarity) which forces drive flange **47** against the drive assembly **150** which, in turn, pulls reciprocating sleeve **60** in a generally proximal direction to close jaw member **110** relative to jaw member **120**. Continued actuation of movable handle **40** forces end **95** of flange **90** farther along ramps **57** and forces the movable handle **40** or cutter lever **700** into a contact **502** of switch **500**, which causes the sealing of tissue **420** to occur. Continued actuation of movable handle **40** then forces movable handle detent **710** into cutter lever **700** to initiate engagement thereof. A detailed discussion of how the sealing occurs, including by electro-mechanical means, is described in commonly-assigned, co-pending U.S. application Ser. No. 10/932,612 entitled "VESSEL SEALING INSTRUMENT WITH ELECTRICAL CUTTING MECHANISM" by Johnson et al., which is hereby incorporated herein.

Continued actuation of movable handle **40** forces end **95** of flange **90** farther along the ramps **57** and into a flexible latch detent **602**. The user feels a resistance when the end **95** contacts the flexible latch detent **602**, which signifies that the device is about to exit the sealing position and either cut or return to its original position without cutting. To cut the tissue seal **450**, the user continues to actuate the movable handle **40**, such that the cutter lever **700** activates knife assembly **140**, which in turn severs the tissue seal **450**. At this cutting stage, the end **95** contacts a detent rib **704** which provides increased resistance to the user indicating that cutting of the tissue is about to begin. The end **95** slides distally along detent rib **704** (in the embodiment shown in FIG. **3**, the detent rib **704** is contacted proximally). When the cut is complete, the detent rib **704** may stop the motion of the end **95** and allow flange **90** to follow its return path **58** (FIG. **26**), as discussed above. Therefore, a full actuation of movable handle **40** grasps and clamps tissue **420**, seals the tissue **420**, and cuts the tissue seal **450**, before returning the movable handle **40** to its original, unactuated position.

FIG. **3** illustrates the forceps **10** with the movable handle **40** located on the distal side of fixed handle **50**. As can be appreciated, the internal dynamics of this embodiment are similar to those of the forceps illustrated in FIGS. **1** and **2**, thus causing the forceps **10** to function in a comparable way.

It is envisioned that the flexible latch detent **602** may include one or more electro-mechanical switches, similar to those of switch **500**, to seal the tissue **420**. In this embodiment, handswitch **500** and contact **502** are not necessary. Details relating to the handswitch are discussed below.

It is also envisioned that latch spring **704** may include one or more mechanical or electro-mechanical switches or activations to drive the knife assembly **140** to cut the tissue seal **450**, such that when end **95** contacts the latch spring **704**, the tissue seal **450** is automatically severed.

The operating features and relative movements of the internal working components of the forceps **10** are shown as phantom lines in the various figures.

As the movable handle **40** is actuated and flange **90** is incorporated into channel **52** of fixed handle **50**, the drive flange **47**, through the mechanical advantage of the above-the-center pivot points, biases a ring flange **154** of drive ring **159** which, in turn, compresses a drive spring **67** against a rear ring **156** of the drive assembly **150** (FIG. **28**). As a result thereof, the rear ring **156** reciprocates sleeve **60** proximally which, in turn, closes jaw member **110** onto jaw member **120**. It is envisioned that the utilization of an over-the-center pivoting mechanism will enable the user to selectively compress the drive spring **67** a specific distance which, in turn, imparts a specific pulling load on the reciprocating sleeve **60** which is converted to a rotational torque about the jaw pivot pin **103**. As a result, a specific closure force can be transmitted to the opposing jaw members **110** and **120**.

FIG. **26** shows the initial actuation of movable handle **40** towards fixed handle **50** which causes the end **95** of flange **90** to move generally proximally and upwardly along entrance pathway **51** (this illustration is the embodiment of the forceps shown in FIG. **3**; the internal environment of the forceps of FIGS. **1** and **2** is similarly situated). During movement of the flange **90** along the entrance and exit pathways **51** and **58**, respectively, the end **95** rides along track **192** along the ramps **57**. Once the tissue **420** is clamped, sealed and cut, end **95** clears edge **193** and movable handle **40** and flange **90** are redirected to exit pathway **58**, where the movable handle **40** returns to its unactuated position.

As mentioned above, the jaw members **110** and **120** may be opened, closed and rotated to manipulate tissue **420** until sealing is desired. This enables the user to position and reposition the forceps **10** prior to activation and sealing. The end effector assembly **100** is rotatable about longitudinal axis "A" through rotation of the rotating assembly **80**. It is envisioned that the feed path of the cable lead **311** through the rotating assembly **80**, along shaft **12** and, ultimately, to the jaw member **110** enables the user to rotate the end effector assembly **100** approximately 180 degrees in both the clockwise and counterclockwise directions without tangling or causing undue strain on cable lead **311**. As can be appreciated, this facilitates the grasping and manipulation of tissue **420**.

Again as best shown in FIGS. **1** and **2**, cutter lever **700** mounts adjacent movable handle **40** and cooperates with the knife assembly **140** to selectively translate knife blade **185** through a tissue seal **450**.

Distal activation of the movable handle **40** (in the embodiment shown in FIGS. **1** and **2**) forces the cutter lever **700** distally, which, as explained in more detail below, ultimately extends the knife blade **185** through the tissue **420**. A knife spring **350** biases the knife assembly **70** in a retracted position such that after severing tissue **420** the knife blade **185** and the knife assembly **70** are automatically returned to a pre-firing position.

Drive assembly **150** includes reciprocating sleeve **60**, drive housing **158**, drive spring **67**, drive ring **159**, drive stop **155** and guide sleeve **157** which all cooperate to form the drive assembly **150**. More particularly and as best shown in FIGS. **22** and **23**, the reciprocating sleeve **60** includes a distal end **65** which as mentioned above has an aperture **62** formed therein for actuating the detent **117** of jaw member **110**. In one embodiment, the distal end **65** includes a scoop-like support member **69** for supporting a proximal end **61** of the fixed jaw member **120** therein. The proximal end **61** of the reciprocating sleeve **60** includes a slot **68** defined therein which is dimensioned to slidingly support the knife assembly **70** for longitudinal reciprocation thereof to sever tissue **420**. The slot **68** also permits retraction of the reciprocating sleeve **60** over the knife assembly **140** during the closing of jaw member **110** relative to jaw member **120**.

The proximal end **61** of the reciprocating sleeve **60** is positioned within an aperture **151** in drive housing **158** to permit selective reciprocation thereof upon actuation of the movable handle **40**. The drive spring **67** is assembled atop the drive housing **158** between a rear stop **156** of the drive housing **158** and a forward stop **154** of the drive ring **159** such that movement of the forward stop **154** compresses the drive spring **67** against the rear stop **156** which, in turn, reciprocates the drive sleeve **60**. As a result thereof, the jaw members **110** and **120** and the movable handle **40** are biased by drive spring **67** in an open configuration. The drive stop **155** is fixedly positioned atop the drive housing **158** and biases the movable handle **40** when actuated such that the drive flange **47** forces the stop **154** of the drive ring **159** proximally against the force of the drive spring **67**. The drive spring **67**, in turn, forces the rear stop **156** proximally to reciprocate the sleeve **60**. In one embodiment, the rotating assembly **80** is located proximal to the drive flange **47** to facilitate rotation of the end effector assembly **100**. The guide sleeve **157** mates with the proximal end **61** of the reciprocating sleeve **60** and affixes to the drive housing **158**. The assembled drive assembly **150** is shown best in FIG. **14**.

As best shown in FIGS. **12** and **15-18**, the knife assembly **140** includes an elongated rod **182** having a bifurcated distal end comprising prongs **182***a* and **182***b* which cooperate to receive a knife bar **184** therein. The knife assembly **180** also includes a proximal end **183** which is keyed to facilitate insertion into tube **160** of the rotating assembly **80**. A knife wheel **148** is secured to the knife bar **182** by a pin **143**. More particularly, the elongated knife rod **182** includes apertures **181***a* and **181***b* which are dimensioned to receive and secure the knife wheel **148** to the knife rod **182** such that longitudinal reciprocation of the knife wheel **148**, in turn, moves the elongated knife rod **182** to sever tissue **420**.

In one embodiment, the knife wheel **148** is donut-like and includes rings **141***a* and **141***b* which define a drive slot **147** designed to receive a drive bar (not shown) such that actuation of the movable handle **40** forces the drive bar and the knife wheel **148** distally. It is envisioned that apertures **181***a* and **181***b* may be used for different configurations. As such, pin **143** is designed for attachment through either aperture **181***a* or **181***b* to mount the knife wheel **148** (see FIG. **18**). Knife wheel **148** also includes a series of radial flanges **142***a* and **142***b* which are dimensioned to slide along both channel **163** of tube **160** and slot **68** of the reciprocating sleeve **60** (see FIG. **9**).

As mentioned above, the knife rod **182** is dimensioned to mount the knife bar **184** between prongs **182***a* and **182***b*, which can be in a friction-fit engagement. The knife bar **184** includes a series of steps **186***a*, **186***b* and **186***c* which reduce the profile of the knife bar **184** towards the distal end thereof. The distal end of the knife bar **184** includes a knife support **188** which is dimensioned to retain knife blade **185**. The end of the knife support **188** can include a chamfered edge **188***a*. It is envisioned that the knife blade **185** may be welded to the knife support **188** or secured in any manner known in the trade.

As best shown in FIGS. **1** and **2**, as the tissue is securely grasped and the cutter lever **700** advances distally due to actuation of movable handle **40**, switch **500** activates, by virtue of movable handle **40** engaging contact **502**. At this point, electrosurgical energy is transferred through cable leads to jaw members **110** and **120**, as described in commonly-assigned, co-pending U.S. application Ser. No.

10/460,926 entitled "VESSEL SEALER AND DIVIDER FOR USE WITH SMALL TROCARS AND CANNULAS" by Dycus et al., which is hereby incorporated by reference in its entirety herein. As can be appreciated from the mechanics of the forceps **10**, the switch **500** cannot fire unless the jaw members **110** and **120** are closed. A sensor (not shown) may be included in the generator or the housing which prevents activation unless the jaw members **110** and **120** have tissue **420** held therebetween. In addition, other sensor mechanisms may be employed which determine pre-surgical, concurrent surgical (i.e., during surgery) and/or post surgical conditions. The sensor mechanisms may also be utilized with a closed-loop feedback system coupled to the electrosurgical generator to regulate the electrosurgical energy based upon one or more pre-surgical, concurrent surgical or post surgical conditions. Various sensor mechanisms and feedback systems are described in commonly-owned, co-pending U.S. patent application Ser. No. 10/427,832 entitled "METHOD AND SYSTEM FOR CONTROLLING OUTPUT OF RF MEDICAL GENERATOR" filed on May 1, 2003 the entire contents of which are hereby incorporated by reference herein.

In one embodiment, the jaw members **110** and **120** are electrically isolated from one another such that electrosurgical energy can be effectively transferred through the tissue **420** to form seal **450**. For example and as best illustrated in FIGS. **24** and **25**, each jaw member, e.g., **110**, includes a uniquely-designed electrosurgical cable path disposed therethrough which transmits electrosurgical energy to the electrically conductive sealing surface **112**. It is envisioned that jaw member **110** may include one or more cable guides or crimp-like electrical connectors to direct cable lead **311** towards electrically conductive sealing surface **112**. In one embodiment, cable lead **311** is held loosely but securely along the cable path to permit rotation of the jaw member **110** about pivot **103**. As can be appreciated, this isolates electrically conductive sealing surface **112** from the remaining operative components of the end effector assembly **100**, jaw member **120** and shaft **12**. The second electrical potential is conducted to jaw member **120** through tube **160**. The two potentials are isolated from one another by virtue of the insulative sheathing surrounding cable lead **311**.

It is contemplated that utilizing a cable feed path for cable lead **311** and by utilizing a conductive tube **160** to carry the first and second electrical potentials not only electrically isolates each jaw member **110** and **120** but also allows the jaw members **110** and **120** to pivot about pivot pin **103** without unduly straining or possibly tangling cable lead **311**. Moreover, it is envisioned that the simplicity of the electrical connections greatly facilitates the manufacturing and assembly process and assures a consistent and tight electrical connection for the transfer of energy through the tissue **420**.

As discussed in commonly-assigned, co-pending U.S. application Ser. No. 10/460,926 entitled "VESSEL SEALER AND DIVIDER FOR USE WITH SMALL TROCARS AND CANNULAS" by Dycus et al., which is hereby incorporated by reference in its entirety herein, it is envisioned that select cable leads are fed through halves **82***a* and **82***b* of the rotating assembly **80** in such a manner to allow rotation of the shaft **12** (via rotation of the rotating assembly **80**) in the clockwise or counter-clockwise direction without unduly tangling or twisting the cable leads. More particularly, select cable leads are fed through a series of conjoining slots **84***a*, **84***b*, **84***c* and **84***d* located in the two halves **82***a* and **82***b* of the rotating assembly **80**. In one embodiment, each conjoining pair of slots, e.g., **84***a*, **84***b* and **84***c*, **84***d*, is large enough to permit rotation of the rotating assembly **80** without unduly straining or tangling the cable leads. The presently disclosed cable lead feed path is envisioned to allow rotation of the rotation assembly approximately 180 degrees in either direction.

Turning back to FIGS. **1-3** which show a view of the housing **20**, rotating assembly **80**, movable handle **40**, fixed handle **50**, latch assembly **600**, switch **500** and cutter lever **700**, it is envisioned that all of these various component parts along with the shaft **12** and the end effector assembly **100** are assembled during the manufacturing process to form a partially and/or fully disposable forceps **10**. For example and as mentioned above, the shaft **12** and/or end effector assembly **100** may be disposable and, therefore, selectively/releasably engagable with the housing **20** and rotating assembly **80** to form a partially disposable forceps **10** and/or the entire forceps **10** may be disposable after use.

Once assembled, drive spring **67** is poised for compression atop drive housing **158** upon actuation of the movable handle **40**. More particularly, movement of the movable handle **40** about pivot point **29** reciprocates the flange **90** into fixed handle **50** and forces drive flange **47** against flange **154** of drive ring **159** to compress drive spring **67** against the rear stop **156** to reciprocate the sleeve **60** (see FIG. **28**).

The switch **500** is prevented from firing before the tissue **420** is clamped by jaw members **110** and **120**. For the sealing to take place, the movable handle **40** should be actuated far enough to contact (or, alternatively, for the cutter lever **700** to contact) the switch **500**, contact **502** or a sensor (not shown). Before the switch **500** is contacted, the movable handle **40** should travel sufficiently far enough to cause jaw members **110** and **120** to be clamped. It is envisioned that the opposing jaw members **110** and **120** may be rotated and partially opened and closed before activation of switch **500** which, as can be appreciated, allows the user to grip and manipulate the tissue **420** before the tissue **420** is sealed.

It is envisioned that configuring the pivot **29** above or relative to a longitudinal axis defined through the shaft provides an increased mechanical advantage, thus facilitating and easing selective compression of the drive spring **67** a specific distance which, in turn, imparts a specific load on the reciprocating sleeve **60**. As best seen in FIG. **2**, the moveable handle **40** includes a drive cam surface **49'** which is designed in-line with the longitudinal axis "A," which together with the position of the pivot **28** being disposed above axis "A," increase the mechanical advantage of the movable handle **40** and reduce the amount of force necessary to actuate the jaw members **110**, **120** with the preferred closure force. The load of the reciprocating sleeve **60** is converted to a torque about the jaw pivot **103**. As a result, a specific closure force can be transmitted to the opposing jaw members **110** and **120** between the range of about 3 kg/cm^2 to about 16 kg/cm^2. As mentioned above, the jaw members **110** and **120** may be opened, closed and rotated to manipulate tissue **420** until sealing is desired. This enables the user to position and reposition the forceps **10** prior to activation and sealing.

Once the desired position for the sealing site is determined and the jaw members **110** and **120** are properly positioned, movable handle **40** may be actuated farther such that the switch **500** is engaged to seal the tissue **420** with electrosurgical energy. Continued actuation of movable handle **40** engages knife assembly **140** (as discussed above), which causes the tissue seal **450** to be severed.

It is envisioned that the end effector assembly **100** and/or the jaw members **110** and **120** may be dimensioned to offload some of the excessive clamping forces to prevent mechanical failure of certain internal operating elements of the end effector **100**.

As can be appreciated, the combination of the increased mechanical advantage provided by the above-the-axis pivot

29 along with the compressive force associated with the drive spring **67** facilitate and assure consistent, uniform and accurate closure pressure about the tissue **420** within the desired working pressure range of about 3 kg/cm^2 to about 16 kg/cm^2 and, preferably, about 7 kg/cm^2 to about 13 kg/cm^2. By controlling the intensity, frequency and duration of the electrosurgical energy applied to the tissue **420**, the user can effectively seal tissue.

In one embodiment, the electrically conductive sealing surfaces **112** and **122** of the jaw members **110** and **120**, respectively, are relatively flat to avoid current concentrations at sharp edges and to avoid arcing between high points. In addition and due to the reaction force of the tissue **420** when engaged, jaw members **110** and **120** can be manufactured to resist bending. For example, the jaw members **110** and **120** may be tapered along the width thereof which is advantageous for two reasons: 1) the taper will apply constant pressure for a constant tissue thickness at parallel; 2) the thicker proximal portion of the jaw members **110** and **120** will resist bending due to the reaction force of the tissue **420**.

As mentioned above, at least one jaw member, e.g., **120**, may include a stop member **750** which limits the movement of the two opposing jaw members **110** and **120** relative to one another. In one embodiment, the stop member **750** extends a predetermined distance from the sealing surface **122** (according to the specific material properties [e.g., compressive strength, thermal expansion, etc.]) to yield a consistent and accurate gap distance "G" during sealing (FIG. **29**). The gap distance between opposing sealing surfaces **112** and **122** during sealing ranges from about 0.001 inches to about 0.006 inches and, desirably, between about 0.002 and about 0.003 inches. It is envisioned that the non-conductive stop members **750** may be molded onto the jaw members **110** and **120** (e.g., overmolding, injection molding, etc.), stamped onto the jaw members **110** and **120** or deposited (e.g., deposition) onto the jaw members **110** and **120**. For example, one technique involves thermally spraying a ceramic material onto the surface of the jaw member **110** and **120** to form the stop members **750**. Several thermal spraying techniques are contemplated which involve depositing a broad range of heat resistant and insulative materials on various surfaces to create stop members **750** for controlling the gap distance between electrically conductive surfaces **112** and **122**.

As energy is being selectively transferred to the end effector assembly **100**, across the jaw members **110** and **120** and through the tissue **420**, a tissue seal **450** forms isolating two tissue halves **420***a* and **420***b*. With other known vessel sealing instruments, the user then removes and replaces the forceps **10** with a cutting instrument (not shown) or manually activates another switch to divide the tissue halves **420***a* and **420***b* along the tissue seal **450**. As can be appreciated, this is both time consuming and tedious and may result in inaccurate tissue division across the tissue seal **450** due to misalignment or misplacement of the cutting instrument along the ideal tissue cutting plane.

As explained in detail above, the present disclosure incorporates a knife assembly **140** which, when activated via the handle assembly **30**, progressively and selectively divides the tissue **420** along an ideal tissue plane in precise manner to effectively and reliably divide the tissue **420** into two sealed halves **420***a* and **420***b* with a tissue gap **475** therebetween (see FIG. **33**). The knife assembly **140** in conjunction with the handle assembly **30** allows the user to quickly separate the tissue **420** immediately after sealing without substituting a cutting instrument through a cannula or trocar port and without having to perform a different action (e.g., manually activating a switch or pulling a trigger). As can be appreciated, accurate sealing and dividing of tissue **420** is accomplished with a single, continuous motion using the same forceps **10**.

It is envisioned that knife blade **185** may also be coupled to the same or an alternative electrosurgical energy source to facilitate separation of the tissue **420** along the tissue seal **450** (not shown). Moreover, it is envisioned that the angle of the tip of the knife blade **185** may be dimensioned to provide more or less aggressive cutting angles depending upon a particular purpose. For example, the knife blade **185** may be positioned at an angle which reduces "tissue wisps" associated with cutting. Moreover, the knife blade **185** may be designed having different blade geometries such as serrated, notched, perforated, hollow, concave, convex etc. depending upon a particular purpose or to achieve a particular result.

From the foregoing and with reference to the various figure drawings, those skilled in the art will appreciate that certain modifications can also be made to the present disclosure without departing from the scope of the same. For example, it may be preferable to add other features to the forceps **10**, e.g., an articulating assembly to axially displace the end effector assembly **100** relative to the elongated shaft **12**.

It is also contemplated that the forceps **10** (and/or the electrosurgical generator used in connection with the forceps **10**) may include a sensor or feedback mechanism (not shown) which automatically selects the appropriate amount of electrosurgical energy to effectively seal the particularly-sized tissue grasped between the jaw members **110** and **120**. The sensor or feedback mechanism may also measure the impedance across the tissue during sealing and provide an indicator (visual and/or audible) that an effective seal has been created between the jaw members **110** and **120**. Examples of such sensor systems are described in commonly-owned U.S. patent application Ser. No. 10/427,832 entitled "METHOD AND SYSTEM FOR CONTROLLING OUTPUT OF RF MEDICAL GENERATOR," filed on May 1, 2003 the entire contents of which are hereby incorporated by reference herein.

Although the figures depict the forceps **10** manipulating an isolated vessel **420**, it is contemplated that the forceps **10** may be used with non-isolated vessels as well. Other cutting mechanisms are also contemplated to cut tissue **420** along the ideal tissue plane.

It is envisioned that the outer surface of the end effector assembly **100** may include a nickel-based material, coating, stamping, metal injection molding which is designed to reduce adhesion between the jaw members **110** and **120** with the surrounding tissue during activation and sealing. Moreover, it is also contemplated that the conductive surfaces **112** and **122** of the jaw members **110** and **120** may be manufactured from one (or a combination of one or more) of the following materials: nickel-chrome, chromium nitride, MedCoat 2000 manufactured by The Electrolizing Corporation of OHIO, inconel 600 and tin-nickel. The tissue conductive surfaces **112** and **122** may also be coated with one or more of the above materials to achieve the same result, i.e., a "non-stick surface." As can be appreciated, reducing the amount that the tissue "sticks" during sealing improves the overall efficacy of the instrument.

One particular class of materials disclosed herein has demonstrated superior non-stick properties and, in some instances, superior seal quality. For example, nitride coatings which include, but not are not limited to: TiN, ZrN, TiAlN, and CrN are preferred materials used for non-stick purposes. CrN has been found to be particularly useful for non-stick purposes due to its overall surface properties and optimal performance. Other classes of materials have also been found to reducing overall sticking. For example, high nickel/chrome

alloys with a Ni/Cr ratio of approximately 5:1 have been found to significantly reduce sticking in bipolar instrumentation. One particularly useful non-stick material in this class is Inconel 600. Bipolar instrumentation having sealing surfaces **112** and **122** made from or coated with Ni200, Ni201 (~100% Ni) also showed improved non-stick performance over typical bipolar stainless steel electrodes.

While several embodiments of the disclosure have been shown in the figures, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. An endoscopic bipolar forceps, comprising:

a housing;

a shaft affixed to the housing, the shaft having a longitudinal axis defined therethrough and an end effector assembly engaged at a distal end thereof, the end effector assembly including two jaw members moveable from a first position in spaced relation relative to one another to at least a second position closer to one another for grasping tissue therebetween, each of the jaw members adapted to connect to an electrosurgical energy source such that the jaw members are capable of conducting energy through tissue held therebetween to affect a tissue seal;

a drive assembly disposed within the housing for moving the jaw members from the first position to the second position;

a switch disposed within the housing which activates the electrosurgical energy source;

a knife assembly which is advanceable to cut tissue disposed between the jaw members;

a movable handle connected to the housing and selectively rotatable about a pivot, the pivot located a fixed distance above the longitudinal axis, wherein continual actuation of the movable handle initially engages the drive assembly to move the jaw members, subsequently engages the switch to activate the electrosurgical energy source to seal the tissue, and subsequently advances the knife assembly to cut tissue disposed between the jaw members.

2. An endoscopic bipolar forceps according to claim **1** further comprising a rotating assembly which rotates the jaw members about the longitudinal axis defined through the shaft.

3. An endoscopic bipolar forceps according to claim **1** wherein at least one of the jaw members includes at least one stop member disposed thereon which regulates the distance between the jaw members.

4. An endoscopic bipolar forceps according to claim **3** wherein the distance between the jaw members is between 0.001 inches and 0.006 inches.

5. An endoscopic bipolar forceps according to claim **1** wherein a pressure range for actuating the movable handle and creating an effective seal is between 3 kg/cm^2 to 16 kg/cm^2.

6. An endoscopic bipolar forceps according to claim **1** further including at least one tactile element which provides tactile feedback to a user relating to at least one of tissue sealing and tissue cutting.

7. An endoscopic bipolar forceps according to claim **1** further comprising a ratchet latch assembly associated with the movable handle and the housing such that the movable handle locks into a first ratchet position after it cooperates to manipulate tissue, and the movable handle locks into a second ratchet position after it cooperates to seal tissue.

8. A method for using an endoscopic bipolar forceps to grasp, seal and cut tissue, the method comprising the steps of:

providing an endoscopic bipolar forceps, the forceps having a housing, a shaft affixed to the housing, the shaft having a longitudinal axis defined therethrough and an end effector assembly engaged at a distal end thereof, the end effector assembly including two jaw members moveable from a first position in spaced relation relative to one another to at least a second position closer to one another for grasping tissue therebetween, each of the jaw members adapted to connect to an electrosurgical energy source such that the jaw members are capable of conducting energy through tissue held therebetween to affect a tissue seal, a drive assembly disposed within the housing for moving the jaw members from the first position to the second position, a switch disposed within the housing which activates the electrosurgical energy source, a knife assembly which is advanceable to cut tissue disposed between the jaw members, and a movable handle connected to the housing and selectively rotatable about a pivot, the pivot located a fixed distance above the longitudinal axis, wherein continual actuation of the movable handle initially engages the drive assembly to move the jaw members, subsequently engages the switch to activate the electrosurgical energy source to seal the tissue, and subsequently advances the knife assembly to cut tissue disposed between the jaw members;

actuating the movable handle, a continued actuation of the movable handle engages the drive assembly and moves the jaw members relative to one another to grasp tissue, engages the switch and activates the electrosurgical energy to seal tissue, and advances the knife assembly to cut the tissue.

9. An surgical instrument for surgically joining tissue, the surgical instrument comprising:

a handle assembly;

a shaft extending distally from the handle assembly and defining a longitudinal axis therethrough;

an end effector assembly disposed at a distal end of the shaft, the end effector assembly including two jaw members moveable from a first position in spaced relation relative to one another to at least a second position closer to one another for grasping tissue therebetween;

a drive assembly disposed in mechanical cooperation with the handle assembly for moving the jaw members between the first position and the second position;

a knife assembly configured to cut tissue disposed between the jaw members;

a tactile element configured to provide feedback to the user after tissue has been joined;

a movable handle disposed in mechanical cooperation with the handle assembly, wherein the movable handle is movable from a first, non-actuated position to a second position where the movable handle engages the drive assembly to move at least one of the jaw members, wherein the movable handle is movable between the second position and a third position to cause tissue to be joined, wherein the movable handle engages the tactile element when the movable handle reaches the third position, wherein the movable handle is movable between the third position and a fourth position where the movable handle engages the knife assembly to cut tissue, and

wherein the movable handle is movable between the third position and the first, non-actuated position without the movable handle moving towards the fourth position.

10. The surgical instrument of claim **9**, wherein each of the jaw members is adapted to connect to an electrosurgical energy source such that the jaw members are capable of conducting energy through tissue held therebetween to affect a tissue seal.

11. The surgical instrument of claim **10**, further comprising a switch disposed within the handle assembly that activates the electrosurgical energy source.

12. The surgical instrument of claim **9**, further comprising a second tactile element, the second tactile element being configured to provide feedback to the user while tissue is being cut.

13. The surgical instrument of claim **12**, wherein the second tactile element is disposed within the handle assembly.

14. The surgical instrument of claim **9**, wherein the tactile element is disposed within the handle assembly.

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